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BIG NEWS ABOUT OUR LATEST ADVANCES IN ROBOTICS SEE INSIDE BACK COVER

Stereo Mixer — this is a really new mixer that enables the constructor DJ to produce a professional performance every time. There are two stereo inputs for magnetic carts, a stereo auxiliary input and mike input. Other plus features are auto-ducking for fast or slow slider controls, auto-mixing, ducking, interrupt, input level control, in short everything that a DJ needs — AND — under £100 complete! Complete kit £97.50 + VAT



TRANSCENDENT 2000 — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice. Complete kit £165.00 + VAT



Versatile modular mixer, featured as a constructional article in Practical Electronics. It can be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input channel has Mic and Line inputs, variable gain, bass and treble controls and a parametric middle frequency equalizer. There are send and return jacks, auxiliary, pan and reverb controls and output and group switching. The output channels have PPM displays for record and studio outputs. The auxiliary channel also has a PPM display and there is a telephone monitor jack and a built-in talk-back microphone. The mixer modules plug into base units each of which takes up to 6 channels. To eliminate hum, the power supply is in a separate cabinet.

SALES COUNTER Collect your order from the factory. Open 9-12/1-4.30 Mon-Fri. Easy parking, no waiting

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flanging, A.D.T., chorus, echo &



vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000! Complete kit (400 mS delay) £130 + VAT Parts for extra 400 mS delay £9.50 + VAT

1 channel £19.90
2 channel £18.50
Auxiliary channel £22.50
Link Panel £3.00

KIT PRICES

1 channel	£19.90	Base unit and wooden front	£27.50
2 channel	£18.50	Pair of mahogany end cheeks	£12.50
Auxiliary channel	£22.50	Power Supply and cabinet	£19.50
Link Panel	£3.00		

All prices are VAT exclusive

TRANSCENDENT POLYSYNTH — A four octave polyphonic synthesiser with outstanding design characteristics, versatility and performance to match. Complete kit £230.00 plus VAT (single voice) or £35.60 plus VAT (up to three more)



Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

MPA 200 — is a low price, high power 100W amplifier. Its smart styling, professional appearance and performance make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit £49.90 + VAT
Chromatèque 5000 — a 3 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit £49.50 + VAT



Component packs for most kits are available. See our great free catalogue, full details of all our range

ETI VOCODER — 14 channels, each with independent level control, for maximum versatility and intelligibility. Two input amplifiers — for speech excitation — each with level control and tone control. The vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit £175.00 + VAT
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FEATURES

DIGEST 11
Our monthly irreverent look at the world of electronics, featuring the return of the caption picture!

MACHINE CODE PROGRAMMING 27
Bob Campbell continues his look at addressing modes with relative and absolute addressing, before pushing and popping the stack are dealt with.

AUDIO DESIGN 37
Tone controls of all different varieties are covered this month, from passive to parametric, and shelf to slope.

CAPACITOR METER REVIEW... 51
Capacitors are amongst the most

common electronic components — but do we ever bother to test them? We do not! Now there's a new meter that could change all that.



TECH TIPS 64
Wanted: a good home (or several good homes) for some good ideas. Apply page 64.

Due to pressure of space, IC Update has been held over until next month.

PROJECTS

A-TO-D BOARD 19
Don't let your analogue voltages go astray — convert them with our cover-feature project into nice, safe digital versions.

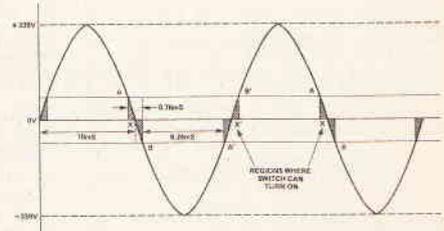
ZX-BASED ALARM 31
RAM the message home to baddies with programmed protection from this project, using either a ZX81 or a Spectrum.

LIGHT CHASER 44
Forget those boring flashing-light displays, here's an EPROM controlled display that will put the competition in the shade!

MODULAR PREAMPLIFIER... 55
So you don't like tone controls? You don't have to have them! So

you want two disc inputs? Easy! So you want to change your mind? That's easy too!

LAMPSAVER 69
Our final project is in the simple but ingenious category — a device to add zero-crossing switching to any light, thus extending bulb life and saving on interference to boot!



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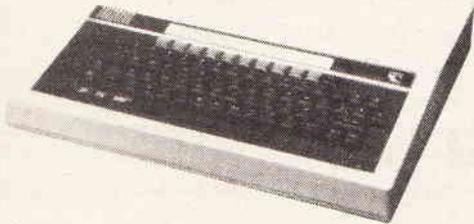
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This board provides 8 high quality 28 pin sockets
for expanding the computer's sideways ROM capacity
by a further 128K. (As 8K Eproms consume
about 40mA on standby and 16K much higher, in
our opinion addition of 8 extra ROMS will not
overload the computer psu nor cause internal
overheating). All ROM sockets are of turned pin
type gold contacts to ensure that numerous inser-
tions and extractions will not wear out or deform
them. The board is fully buffered and also dimen-
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board components. Full fitting instructions
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For little more than the cost of an 800K disc drive,
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gives you 64K of memory and includes a database,
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sional business software. **£825 + £8 p&p.**

Special offer from Torch: free software worth
£1,000, for a limited period only and subject to
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*CP/M is a trademark of Digital Research.

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No. of ways	MALE	FEMALE
9	80p	105p
15	150p	160p
25	210p	200p
37	250p	335p
	165p	215p
	90p	85p
	100p	100p
	385p	450p

TEXTOL ZIF

SOCKETS	24-pin	40-pin
28-pin	£8.00	£9.75

DIL SWITCHES

4-way	70p	8-way	90p
6-way	85p	10-way	140p

JUMPER LEADS

24" Ribbon Cable with Headers

1 end	14-pin	16-pin	24-pin	40-pin
2 ends	145p	165p	240p	350p
	210p	230p	345p	540p

24" Ribbon Cable with Sockets

1 end	20-pin	26-pin	34-pin	40-pin
2 ends	160p	200p	280p	300p
	290p	370p	480p	525p

Ribbon Cable with D. Conn.
25-way Male **500p** Female **550p**

RS 232 JUMPERS

(25-way D)

24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female-Female	£10.00
24" Male-Male	£9.50
24" Male-Female	£9.50

DIL HEADERS

Solder Type	IDC Type
14pin	40p
16pin	50p
24pin	100p
40pin	200p
	110p
	150p
	225p

AMPHENOL CONNECTORS

36-way plug Centronics Parallel
Solder **£5.25** IDC **£4.95**
36-way socket Centronics Parallel
Solder **£5.50** IDC **£5.20**
24-way plug IEEE Solder **£5**
IDC **£4.75**
24-way socket IEEE Solder **£5**

RIBBON CABLE

(Grey/meter)

10-way	40p
16-way	60p
20-way	85p
26-way	120p
34-way	160p
40-way	180p
50-way	200p
64-way	280p

EURO CONNECTORS

DIN 41617	Plug	Skt.
21-way	160p	165p
31-way	170p	170p
DIN 41617		
2 x 32-way St. Pin	220p	275p
2 x 32-way Ang. Pin	275p	320p
3 x 32-way St. Pin	260p	300p
3 x 32-way Ang. Pin	375p	350p

EDGE CONNECTORS

2 x 18-way	0.1"	0.156"
2 x 22-way	190p	240p
2 x 23-way	175p	-
2 x 25-way	225p	220p
2 x 28-way	190p	-
1 x 43-way	260p	-
2 x 43-way	365p	-
1 x 77-way	600p	-
5100 Conn		600p

TEST CLIPS

14-pin	275p	16-pin	£3
40-pin	£6		

DISC DRIVES FOR THE FORTH COMPUTER

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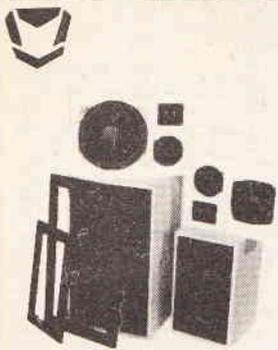
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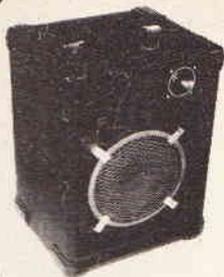
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Price £13.90 each + £1.50 P & P.

Designer approved flat pack cabinet kits including grill fabric. Can be finished with iron on veneer or self adhesive vinyl etc.
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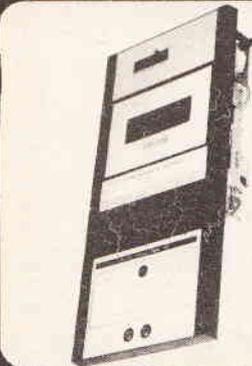
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3 watt FM Transmitter



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 12" 100 watt R.M.S. Impedance 8 ohms. 50 oz magnet 2" aluminium voice coil. Res. Freq. 25Hz. Freq. Resp. to 4 KHz. Sens. 95dB. Price: **£24.50 each + £3.00 P&P.**
 8" 50 watt R.M.S. Impedance 8 ohms. 20 oz magnet 1 1/2" aluminium voice coil. Res. Freq. 40Hz. Freq. Resp. to 6 KHz. Sens. 92dB. Black Cone. Price: **£9.50 each**. Also available with black protective grille. Price: **£9.99 each P&P £1.50.**

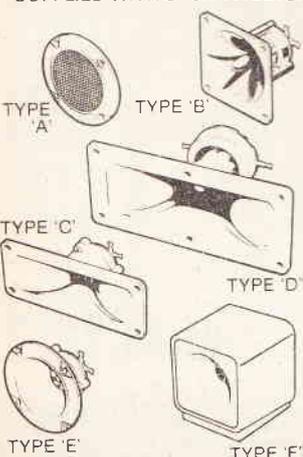


12" 85 watt R.M.S. MCKENZIE C1285GP (LEAD GUITAR, KEYBOARD, DISCO) 2" aluminium voice coil, aluminium centre dome, 8 ohm imp., Res. Freq. 45Hz., Freq. Resp. to 6.5KHz. Sens. 98dB. Price: **£23.00 + £3 carriage.**
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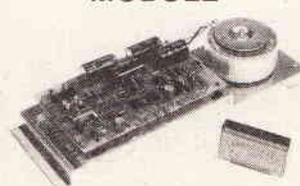
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OMP POWER AMPLIFIER MODULE



New model.
 Improved specification

NEW OMP100 MK.II POWER AMPLIFIER MODULE Power Amplifier Module complete with integral heat sink toroidal transformer power supply and glass fibre p.c.b. assembly. Incorporates drive circuit to power a compatible LED Vu meter. New improved specification makes this amplifier ideal for P.A., instrumental and Hi-Fi applications.
SPECIFICATION
 Output Power:— 110 watts R.M.S.
 Loads:— Open and short circuit proof 4/16 ohms.
 Frequency Response:— 15Hz - 30KHz -3dB.
 T.H.D.:— 0.01%.
 S.N.R. (Unweighted):— -118dB ±3.5dB
 Sensitivity for Max Output:— 500mV @ 10K.
 Size:— 360 x 115 x 72 mm. Price:— **£31.99 + £2.00 P&P.** Vu Meter Price:— **£7.00 + 50p P&P.**

MOSFET versions available up to 300W. R.M.S.

HOME PROTECTION SYSTEM

Better to be 'Alarmed' than terrified. Thandar's famous 'Minder' Burglar Alarm System. Superior microwave principle. Supplied as three units, complete with interconnection cable. FULLY GUARANTEED.

Control Unit — Houses microwave radar unit, range up to 15 metres adjustable by sensitivity control. Three position, key operated fascia switch — off — test — armed. 30 second exit and entry delay.
 Indoor alarm — Electronic swept freq. siren, 104dB output.
 Outdoor Alarm — Electronic swept freq. siren 98dB output. Housed in a tamper-proof heavy duty metal case.
 Both the control unit and outdoor alarm contain rechargeable batteries which provide full protection during mains failure. Power requirement 200/260 Volt AC 50/60Hz. Expandable with door sensors, panic buttons etc. Complete with instructions

SAVE £128 Usual price £228.85

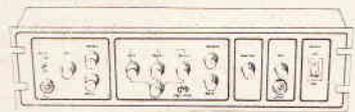
BKE's PRICE **£99 p&p £4**

SAE for colour brochure



MIXERS DISCO

OMP PRO MIX MONO

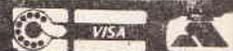


OMP PROMIX MONO DISCO MIXER (As illustrated). 4 Inputs: — 2 Mag. Disc. 1 Aux plus Mic. with override. Active bass and treble tone cont's. Individual level controls plus master volume. Monitor output (headphone) for all inputs. Output: 775mV Supply 240Vac. Size: 19" x 5 1/4" x 2 1/2". Price: **£49.99 + £2.00 P&P**

ALSO Stereo Version as above price **£69.99 + £2 p&p**

B.K. ELECTRONICS

UNIT 5, COMET WAY, SOUTHEND-ON-SEA, ESSEX, SS2 6TR



★ SAE for current lists. ★ Official orders welcome. ★ All prices include VAT. ★ Sales Counter. ★ All items packed where applicable in special energy absorbing PU foam. ★ Please phone 0702 527572 ★

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ACCESS AND BARCLAYCARD WELCOME

LINEAR		LM339		LM3911		NE566		TL064	
556CMOS	80	ICL7106	680	LM348	60	LM3914	125	NE567	100
556CMOS	150	ICL7611	95	LM358	50	LM3915	225	NE570	370
709	25	ICL7622	180	LM377	170	LM3916	105	NE571	370
741	14	ICL7622	180	LM382	120	MC1496	68	RC4136	55
748	35	ICL8038	295	LM383	120	MC3340	135	RC4558	40
9400CJ	350	ICL8211A	200	LM386	90	ML922	40	SL480	170
AY-3-1270	70	ICM7224	785	LM387	120	ML924	195	SL7601B	150
AY-3-8910	370	ICM7555	80	LM393	40	ML925	210	ULN2003	70
AY-3-8912	540	LF351	45	LM394	40	ML926	140	SP8529	250
CA3046	60	LF353	85	LM711	60	ML928	140	TBA1205	70
CA3080	65	LF356	90	LM725	350	ML929	140	TBA800	75
CA3089	190	LM110	325	LM733	75	MM5387A	465	TBA810	96
CA3080A375	LM301A	25	LM741	14	NE529	225	TBA820	70	ZN423
CA3130E	85	LM313	120	LM747	60	NE531	140	TBA950	220
CA3140E	36	LM318	120	LM748	60	NE544	205	TDA1022	490
CA3161E	100	LM324	30	LM917	200	NE555	16	TDA1024	125
CA3189	290	LM334Z	100	LM9300	45	NE556	45	TL061	40
CA3240E	100	LM335Z	125	LM9309	75	NE565	110	TL062	60

TRANSISTORS		BC517		BF337		MPSU56		ZTX108	
AC128	30	BC149	9	BC547	7	BF440	23	TIP29A	30
AC127	30	BC157	8	BC548	10	BF480	10	TIP29B	55
AC128	30	BC158	10	BC549	10	BF481	20	TIP29C	37
AC128	20	BC159	8	BC549	10	BF482	25	TIP30A	35
AC176	25	BC160	45	BC549	10	BF483	25	TIP30B	50
AC187	22	BC168C	10	BC549	10	BF484	25	TIP30C	37
AC188	22	BC169C	10	BC549	10	BF485	25	TIP30D	37
AD142	120	BC170	8	BC549	10	BF486	25	TIP30E	37
AD149	80	BC171	10	BC549	10	BF487	25	TIP30F	37
AD181	40	BC172	8	BC549	10	BF488	25	TIP30G	37
AD182	40	BC177	18	BC549	10	BF489	25	TIP30H	37
AF124	60	BC178	18	BC549	10	BF490	25	TIP30I	37
AF126	60	BC179	18	BC549	10	BF491	25	TIP30J	37
AF139	40	BC182	10	BC549	10	BF492	25	TIP30K	37
AF186	70	BC182L	8	BC549	10	BF493	25	TIP30L	37
AF239	75	BC183	10	BC549	10	BF494	25	TIP30M	37
BC107	10	BC183L	10	BC549	10	BF495	25	TIP30N	37
BC107B	12	BC184	10	BC549	10	BF496	25	TIP30O	37
BC108	12	BC184L	10	BC549	10	BF497	25	TIP30P	37
BC108B	12	BC185	10	BC549	10	BF498	25	TIP30Q	37
BC109	12	BC212L	10	BC549	10	BF499	25	TIP30R	37
BC109C	12	BC213L	10	BC549	10	BF500	25	TIP30S	37
BC114	18	BC214	10	BC549	10	BF501	25	TIP30T	37
BC115	22	BC214L	8	BC549	10	BF502	25	TIP30U	37
BC117	18	BC237	14	BC549	10	BF503	25	TIP30V	37
BC119	35	BC238	14	BC549	10	BF504	25	TIP30W	37
BC137	40	BC308	12	BC549	10	BF505	25	TIP30X	37
BC139	40	BC327	14	BC549	10	BF506	25	TIP30Y	37
BC140	28	BC328	14	BC549	10	BF507	25	TIP30Z	37
BC141	30	BC337	14	BC549	10	BF508	25	TIP30A	37
BC142	25	BC339	14	BC549	10	BF509	25	TIP30B	37
BC143	25	BC347	30	BC549	10	BF510	25	TIP30C	37
BC147	8	BC478	30	BC549	10	BF511	25	TIP30D	37
BC148	8	BC479	30	BC549	10	BF512	25	TIP30E	37

CABLES		20 metre pack single core		HARDWARE		CAPACITORS	
20 metre pack single core	connecting cable ten different colours, 75p	PP3 battery clips	6	Polyester, radial leads, 250v, C280	0.01, 0.015, 0.022, 0.033 - 6	0.022, 0.033, 0.047 - 13p, 0.68 - 20p, 1u - 23p	0.01, 0.015, 0.022, 0.033 - 6
Speaker cable	10p/m	Red or black crocodile clips	15	Black pointer contact knob	6	Pr Ultrasonic transducers	390
Standard screened	15p/m	6V Electronic buzzer	60	12V Electronic buzzer	65	12V Piezo transducer	75
Twin screened	24p/m	12V Electronic buzzer	65	12V Piezo transducer	75	64mm 64 ohm speaker	70
2.5A 3 core mains	23p/m	12V Piezo transducer	75	64mm 8 ohm speaker	70	20mm panel fuseholder	25
10 way rainbow ribbon	26p/ft	64mm 64 ohm speaker	70	64mm 8 ohm speaker	70		
20 way rainbow ribbon	47p/ft	64mm 8 ohm speaker	70				
10 way grey ribbon	14p/ft						
20 way grey ribbon	28p/ft						

REGULATORS		78L05		78L12		78L15		78L18	
78L05	30	78L05	45	78L12	30	78L12	45	78L15	35
78L12	30	78L12	45	78L15	35	78L15	45	78L18	35
7805	35	7905	40	7815	35	7915	40	7818	35
7815	35	7915	40	7818	35	7918	40	7820	35
LM309K	130	LM723	35	LM317	90	LM317Z	90	LM323K	420

TRIACS		400V 6A		400V 16A		400V 4A	
400V 6A	65	400V 16A	65	400V 4A	50	BR100	25

OPTO		3mm red		5mm red		3mm green		5mm green	
3mm red	7	5mm red	7	3mm green	7	5mm green	7	3mm yellow	10
3mm green	10	5mm green	10	3mm yellow	10	5mm yellow	10	3mm blue	10
3mm yellow	10	5mm yellow	10	3mm blue	10	5mm blue	10	3mm white	10

CMOS		4016		4017		4018		4019	
4016	20	4017	20	4018	20	4019	20	4020	20
4020	10	4021	10	4022	10	4023	10	4024	10
4021	10	4022	10	4023	10	4024	10	4025	10
4022	10	4023	10	4024	10	4025	10	4026	10

MINI-D CONNECTORS		9 way		15 way		25 way		37 way	
Plugs solder lugs	60p	85p	125p	170p	210p	250p	350p	450p	550p
Right angle	120p	150p	240p	290p	380p	470p	560p	650p	740p
Sockets	90p	130p	195p	250p	310p	375p	440p	505p	570p
Right angle	160p	210p	280p	340p	400p	460p	520p	580p	640p
Covers	100p	90p	100p	110p	120p	130p	140p	150p	160p

CONNECTORS		DIN Plug		Skt Jack		Plug Skt	
DIN Plug <td>50p</td> <td>Skt Jack <td>50p</td> <td>Plug Skt <td>50p</td> <td>2 pin <td>9p</td> </td></td></td>	50p	Skt Jack <td>50p</td> <td>Plug Skt <td>50p</td> <td>2 pin <td>9p</td> </td></td>	50p	Plug Skt <td>50p</td> <td>2 pin <td>9p</td> </td>	50p	2 pin <td>9p</td>	9p
2 pin <td>9p</td> <td>3 pin <td>12p</td> <td>4 pin <td>15p</td> <td>5 pin <td>18p</td> </td></td></td>	9p	3 pin <td>12p</td> <td>4 pin <td>15p</td> <td>5 pin <td>18p</td> </td></td>	12p	4 pin <td>15p</td> <td>5 pin <td>18p</td> </td>	15p	5 pin <td>18p</td>	18p
3 pin <td>12p</td> <td>6 pin <td>21p</td> <td>7 pin <td>24p</td> <td>8 pin <td>27p</td> </td></td></td>	12p	6 pin <td>21p</td> <td>7 pin <td>24p</td> <td>8 pin <td>27p</td> </td></td>	21p	7 pin <td>24p</td> <td>8 pin <td>27p</td> </td>	24p	8 pin <td>27p</td>	27p
4 pin <td>15p</td> <td>9 pin <td>30p</td> <td>10 pin <td>33p</td> <td>11 pin <td>36p</td> </td></td></td>	15p	9 pin <td>30p</td> <td>10 pin <td>33p</td> <td>11 pin <td>36p</td> </td></td>	30p	10 pin <td>33p</td> <td>11 pin <td>36p</td> </td>	33p	11 pin <td>36p</td>	36p
5 pin <td>18p</td> <td>12 pin <td>39p</td> <td>12 pin <td>42p</td> <td>13 pin <td>45p</td> </td></td></td>	18p	12 pin <td>39p</td> <td>12 pin <td>42p</td> <td>13 pin <td>45p</td> </td></td>	39p	12 pin <td>42p</td> <td>13 pin <td>45p</td> </td>	42p	13 pin <td>45p</td>	45p
6 pin <td>21p</td> <td>14 pin <td>48p</td> <td>14 pin <td>51p</td> <td>15 pin <td>54p</td> </td></td></td>	21p	14 pin <td>48p</td> <td>14 pin <td>51p</td> <td>15 pin <td>54p</td> </td></td>	48p	14 pin <td>51p</td> <td>15 pin <td>54p</td> </td>	51p	15 pin <td>54p</td>	54p
7 pin <td>24p</td> <td>16 pin <td>57p</td> <td>16 pin <td>60p</td> <td>17 pin <td>63p</td> </td></td></td>	24p	16 pin <td>57p</td> <td>16 pin <td>60p</td> <td>17 pin <td>63p</td> </td></td>	57p	16 pin <td>60p</td> <td>17 pin <td>63p</td> </td>	60p	17 pin <td>63p</td>	63p
8 pin <td>27p</td> <td>18 pin <td>66p</td> <td>18 pin <td>69p</td> <td>19 pin <td>72p</td> </td></td></td>	27p	18 pin <td>66p</td> <td>18 pin <td>69p</td> <td>19 pin <td>72p</td> </td></td>	66p	18 pin <td>69p</td> <td>19 pin <td>72p</td> </td>	69p	19 pin <td>72p</td>	72p
9 pin <td>30p</td> <td>20 pin <td>75p</td> <td>20 pin <td>78p</td> <td>21 pin <td>81p</td> </td></td></td>	30p	20 pin <td>75p</td> <td>20 pin <td>78p</td> <td>21 pin <td>81p</td> </td></td>	75p	20 pin <td>78p</td> <td>21 pin <td>81p</td> </td>	78p	21 pin <td>81p</td>	81p
10 pin <td>33p</td> <td>22 pin <td>84p</td> <td>22 pin <td>87p</td> <td>23 pin <td>90p</td> </td></td></td>	33p	22 pin <td>84p</td> <td>22 pin <td>87p</td> <td>23 pin <td>90p</td> </td></td>	84p	22 pin <td>87p</td> <td>23 pin <td>90p</td> </td>	87p	23 pin <td>90p</td>	90p
11 pin <td>36p</td> <td>24 pin <td>93p</td> <td>24 pin <td>96p</td> <td>25 pin <td>99p</td> </td></td></td>	36p	24 pin <td>93p</td> <td>24 pin <td>96p</td> <td>25 pin <td>99p</td> </td></td>	93p	24 pin <td>96p</td> <td>25 pin <td>99p</td> </td>	96p	25 pin <td>99p</td>	99p
12 pin <td>39p</td> <td>26 pin <td>102p</td> <td>26 pin <td>105p</td> <td>27 pin <td>108p</td> </td></td></td>	39p	26 pin <td>102p</td> <td>26 pin <td>105p</td> <td>27 pin <td>108p</td> </td></td>	102p	26 pin <td>105p</td> <td>27 pin <td>108p</td> </td>	105p	27 pin <td>108p</td>	108p
13 pin <td>42p</td> <td>28 pin <td>111p</td> <td>28 pin <td>114p</td> <td>29 pin <td>117p</td> </td></td></td>	42p	28 pin <td>111p</td> <td>28 pin <td>114p</td> <td>29 pin <td>117p</td> </td></td>	111p	28 pin <td>114p</td> <td>29 pin <td>117p</td> </td>	114p	29 pin <td>117p</td>	117p
14 pin <td>45p</td> <td>30 pin <td>120p</td> <td>30 pin <td>123p</td> <td>31 pin <td>126p</td> </td></td></td>	45p	30 pin <td>120p</td> <td>30 pin <td>123p</td> <td>31 pin <td>126p</td> </td></td>	120p	30 pin <td>123p</td> <td>31 pin <td>126p</td> </td>	123p	31 pin <td>126p</td>	126p
15 pin <td>48p</td> <td>32 pin <td>129p</td> <td>32 pin <td>132p</td> <td>33 pin <td>135p</td> </td></td></td>	48p	32 pin <td>129p</td> <td>32 pin <td>132p</td> <td>33 pin <td>135p</td> </td></td>	129p	32 pin <td>132p</td> <td>33 pin <td>135p</td> </td>	132p	33 pin <td>135p</td>	135p
16 pin <td>51p</td> <td>34 pin <td>138p</td> <td>34 pin <td>141p</td> <td>35 pin <td>144p</td> </td></td></td>	51p	34 pin <td>138p</td> <td>34 pin <td>141p</td> <td>35 pin <td>144p</td> </td></td>	138p	34 pin <td>141p</td> <td>35 pin <td>144p</td> </td>	141p	35 pin <td>144p</td>	144p
17 pin <td>54p</td> <td>36 pin <td>147p</td> <td>36 pin <td>150p</td> <td>37 pin <td>153p</td> </td></td></td>	54p	36 pin <td>147p</td> <td>36 pin <td>150p</td> <td>37 pin <td>153p</td> </td></td>	147p	36 pin <td>150p</td> <td>37 pin <td>153p</td> </td>	150p	37 pin <td>153p</td>	153p
18 pin <td>57p</td> <td>38 pin <td>156p</td> <td>38 pin <td>159p</td> <td>39 pin <td>162p</td> </td></td></td>	57p	38 pin <td>156p</td> <td>38 pin <td>159p</td> <td>39 pin <td>162p</td> </td></td>	156p	38 pin <td>159p</td> <td>39 pin <td>162p</td> </td>	159p	39 pin <td>162p</td>	162p
19 pin <td>60p</td> <td>40 pin <td>165p</td> <td>40 pin <td>168p</td> <td>41 pin <td>171p</td> </td></td></td>	60p	40 pin <td>165p</td> <td>40 pin <td>168p</td> <td>41 pin <td>171p</td> </td></td>	165p	40 pin <td>168p</td> <td>41 pin <td>171p</td> </td>	168p	41 pin <td>171p</td>	171p
20 pin <td>63p</td> <td>42 pin <td>174p</td> <td>42 pin <td>177p</td> <td>43 pin <td>180p</td> </td></td></td>	63p	42 pin <td>174p</td> <td>42 pin <td>177p</td> <td>43 pin <td>180p</td> </td></td>	174p	42 pin <td>177p</td> <td>43 pin <td>180p</td> </td>	177p	43 pin <td>180p</td>	180p
21 pin <td>66p</td> <td>44 pin <td>183p</td> <td>44 pin <td>186p</td> <td>45 pin <td>189p</td> </td></td></td>	66p	44 pin <td>183p</td> <td>44 pin <td>186p</td> <td>45 pin <td>189p</td> </td></td>	183p	44 pin <td>186p</td> <td>45 pin <td>189p</td> </td>	186p	45 pin <td>189p</td>	189p
22 pin <td>69p</td> <td>46 pin <td>192p</td> <td>46 pin <td>195p</td> <td>47 pin <td>198p</td> </td></td></td>	69p	46 pin <td>192p</td> <td>46 pin <td>195p</td> <td>47 pin <td>198p</td> </td></td>	192p	46 pin <td>195p</td> <td>47 pin <td>198p</td> </td>	195p	47 pin <td>198p</td>	198p
23 pin <td>72p</td> <td>48 pin <td>201p</td> <td>48 pin <td>204p</td> <td>49 pin <td>207p</td> </td></td></td>	72p	48 pin <td>201p</td> <td>48 pin <td>204p</td> <td>49 pin <td>207p</td> </td></td>	201p	48 pin <td>204p</td> <td>49 pin <td>207p</td> </td>	204p	49 pin <td>207p</td>	207p
24 pin <td>75p</td> <td>50 pin <td>210p</td> <td>50 pin <td>213p</td> <td>51 pin <td>216p</td> </td></td></td>	75p	50 pin <td>210p</td> <td>50 pin <td>213p</td> <td>51 pin <td>216p</td> </td></td>	210p	50 pin <td>213p</td> <td>51 pin <td>216p</td> </td>	213p	51 pin <td>216p</td>	216p
25 pin <td>78p</td> <td>52 pin <td>219p</td> <td>52 pin <td>222p</td> <td>53 pin <td>225p</td> </td></td></td>	78p	52 pin <td>219p</td> <td>52 pin <td>222p</td> <td>53 pin <td>225p</td> </td></td>	219p	52 pin <td>222p</td> <td>53 pin <td>225p</td> </td>	222p	53 pin <td>225p</td>	225p
26 pin <td>81p</td> <td>54 pin <td>228p</td> <td>54 pin <td>231p</td> <td>55 pin <td>234p</td> </td></td></td>	81p	54 pin <td>228p</td> <td>54 pin <td>231p</td> <td>55 pin <td>234p</td> </td></td>	228p	54 pin <td>231p</td> <td>55 pin <td>234p</td> </td>	231p	55 pin <td>234p</td>	234p
27 pin <td>84p</td> <td>56 pin <td>237p</td> <td>56 pin <td>240p</td> <td>57 pin <td>243p</td> </td></td></td>	84p	56 pin <td>237p</td> <td>56 pin <td>240p</td> <td>57 pin <td>243p</td> </td></td>	237p	56 pin <td>240p</td> <td>57 pin <td>243p</td> </td>	240p	57 pin <td>243p</td>	243p
28 pin <td>87p</td> <td>58 pin <td>246p</td> <td>58 pin <td>249p</td> <td>59 pin <td>252p</td> </td></td></td>	87p	58 pin <td>246p</td> <td>58 pin <td>249p</td> <td>59 pin <td>252p</td> </td></td>	246p	58 pin <td>249p</td> <td>59 pin <td>252p</td> </td>	249p	59 pin <td>252p</td>	252p
29 pin <td>90p</td> <td>60 pin <td>255p</td> <td>60 pin <td>258p</td> <td>61 pin <td>261p</td> </td></td></td>	90p	60 pin <td>255p</td> <td>60 pin <td>258p</td> <td>61 pin <td>261p</td> </td></td>	255p	60 pin <td>258p</td> <td>61 pin <td>261p</td> </td>	258p	61 pin <td>261p</td>	261p
30 pin <td>93p</td> <td>62 pin <td>264p</td> <td>62 pin <td>267p</td> <td>63 pin <td>270p</td> </td></td></td>	93p	62 pin <td>264p</td> <td>62 pin <td>267p</td> <td>63 pin <td>270p</td> </td></td>	264p	62 pin <td>267p</td> <td>63 pin <td>270p</td> </td>	267p	63 pin <td>270p</td>	270p
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41 pin <td>126p</td> <td>84 pin <td>363p</td> <td>84 pin <td>366p</td> <td>85 pin <td>369p</td> </td></td></td>	126p	84 pin <td>363p</td> <td>84 pin <td>366p</td> <td>85 pin <td>369p</td> </td></td>	363p	84 pin <td>366p</td> <td>85 pin <td>369p</td> </td>	366p	85 pin <td>369p</td>	369p
42 pin <td>129p</td> <td>86 pin <td>372p</td></td>	129p	86 pin <td>372p</td>	372p				

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K2572	Universal 4 Digit U/D counter with memory	44.72
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K2577	Universal Start/Stop Timer	7.45
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Z80A CTC	3.20
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2708	3.00
2716	3.20
2732	7.50
2532	3.50
2764(200ns)	11.00
ADC0816 (8 bit)	14.90

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INTERNATIONAL

AUDIO DESIGN

This month, audio design reaches the seat of the mystique surrounding the whole topic of audio amplifiers — the design of the power section. In true ETI fashion, we intend to boldly separate fact from fiction, truth from fantasy, and infinitives from their verbs!

VECTORGRAPHICS

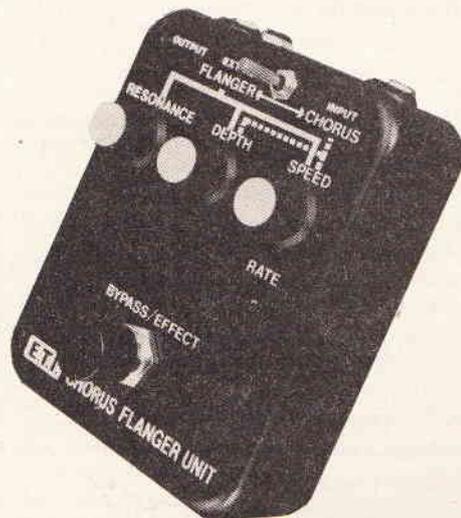
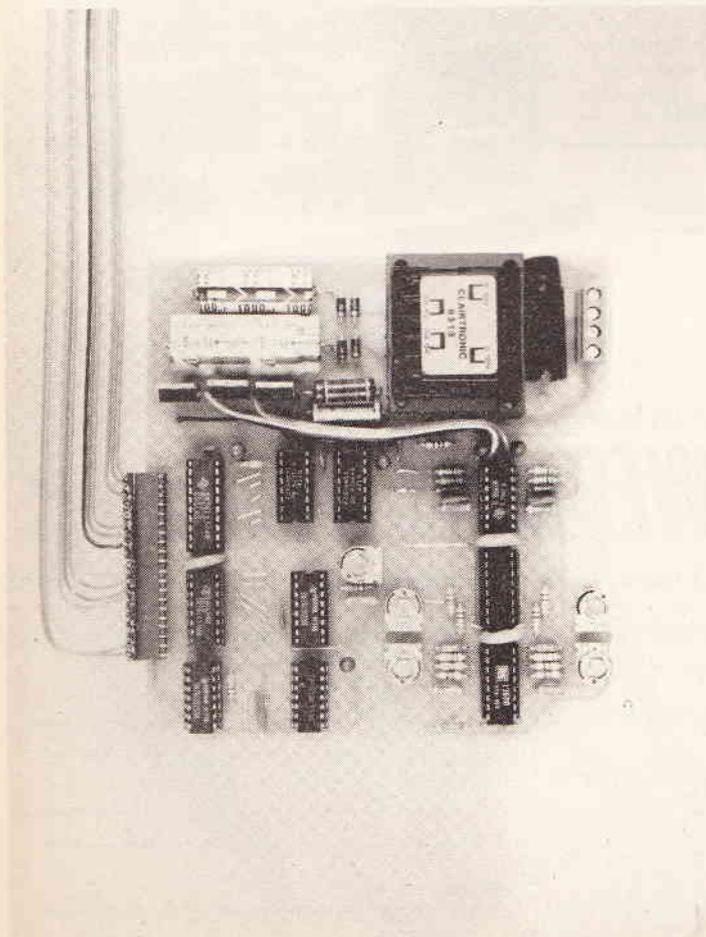
There is an alternative to using a raster-scanned display — that of using vectors drawn across the screen directly. Phil Walker has produced a system for experimenters to play with, using a ZX81.

EPROM PROGRAMMING

We were so overwhelmed with requests for photocopies of the assembler listing for the EPROM programmer published in our August issue that we asked Mike Bedford to produce some notes on how to interconvert the program for other home computers. We'll be published this, along with the listing for the benefit of the very few of our readers who have not already requested it from us!

CHORUS/FLANGER

This project is designed by Tim Orr — who has absented himself from our pages for a while, but has recently learned better. It's for a chorus/flanger unit that can be used with guitar, bass guitar, high-output microphone, keyboards, or, in fact, almost anything that you can attach to a jack-plug.



LOOK OUT FOR THE JANUARY ISSUE
ON SALE DECEMBER 2nd

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

ETI DECEMBER 1983

BUILD YOUR OWN

CORTEX

16 bit, 64K RAM colour computer



With this powerful machine (featured in Electronics Today International as a constructional project) you have access to highly advanced systems and software developed specially by MPE Ltd for the CORTEX. For business, education, R & D – or simply increasing your knowledge and understanding of computers – it beats comparably priced off-the-shelf machines hands down!

Standard features –

- High speed 24K byte extended basic interpreter
- Powerful TMS9995 16 bit microprocessor
- 48 bit floating point gives 11 digit accuracy
- High resolution (256 x 192) colour graphics
- Screen memory does not use up user memory space
- 16 colours available on the screen together in graphic mode
- Fast line drawing and point plotting basic commands
- High speed colour shape manipulation from basic
- Full textual error messages
- String and Array size limited only by memory size
- Real time clock included in basic
- Interval timing with 10mS resolution via TIC function
- Named load and save of basic or machine code programs
- Auto-run available for any program
- Powerful machine code monitor
- Assembler and Disassembler included as standard
- Auto line numbering facility
- Full renumber command
- Simple but powerful line editor
- Buffered i/o allows you to continue executing the program while still printing
- Flexible CALL statement allows linkage to machine code routines with up to 12 parameters
- Basic programs may contain spaces between key words to make programs readable without using more memory
- Over 34K bytes available for basic programs
- Extended basic includes IF-THEN-ELSE
- Supports up to 16 output devices: Screen and cassette interfaces included as standard
- Supports bit manipulation of variables from basic
- Error trapping to a basic routine included
- Basic supports Hexadecimal numbers
- Separate 16K video RAM for graphics

STATEMENTS	PRINT	TIME	RENUM	MAG	MWD	U	INT	POS
IF	WAIT	WAIT	BOOT	TOF	BASE	@	LOG	COL
ELSE	SAVE	SAVE	GRAPH	TON	COMMAN	U	SOR	MOD
ON	LOAD	LOAD	TEXT	DIM	RUN	#	SYS	RND
GOTO	1 UNIT	MOTOR	PLOT	LET	SIZE	FUNCTIO	TIC	KEY
GOSUB	BAUD	ESCAPE	UNPLOT	DEF	CON	ABS	SGN	OPERATORS
POP	CALL	NOESC	COLOUR	MON	NEW	ADR	BIT	OR
REM	DATA	RANDOM	CHAR	END	DELIMITERS	ASC	CRB	LOR
FOR	READ	ENTER	SPRITE	BIT	TO	ATN	CRF	AND
NEXT	RESTOR	LIST	SHAPE	CRB	TAB	SIN	MEM	LAND
ERROR	RETURN	PURGE	SPUT	CRF	STEP	COS	MWD	NOT
INPUT	STOP	NUMBER	SGET	MEM	THEN	EXP	LEN	LNOT
						FRA	MCH	LXOR

Self assembly kit

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Optional extras

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Pair of 5 1/4" disc drives and hardware kit	£365.00	+ RS232C £410.00
		CORTEX C – as above + disc drives £895.00

Full assembly instructions and 216 page user's manual.

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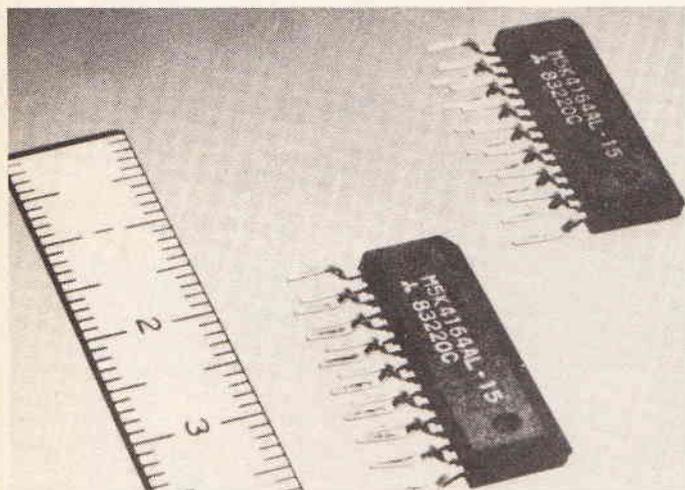
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DIGEST



ZIL-Package 64K DRAMs

Mitsubishi Electric Corporation has put on the market the first 64-kilobit dynamic random access memory (DRAM) in a 16-pin, zigzag in-line (ZIL) package for high-density installation.

The plastic-mold ZIL-package 64K DRAM is available in 120ns and 150ns versions, and is designed to achieve high-density installation at prices similar to those of existing plastic mold dual in-line package chips. The ZIL package measures 20.2 mm in length, 2.8 mm in width and 8.3

mm in height. Space required for installation is 56.6mm², about 47% of the space required for the company's existing dual in-line package chip.

Mitsubishi Electric plans to sell the new 64K DRAMs to makers of high-resolution graphic displays, mainframe computers and other products requiring high-density installation of chips. Mitsubishi Electric Corporation, 18th Floor, Centre Point, 103 New Oxford Street, London W2, tel 01-379 7160.

Home Made Bread?

If you're coming to Breadboard this year (what do you mean, it? — ED.) better make sure you have a hand free. You might be the lucky person who carries off A.B. Engineering's superb tool kit.

Worth over £100, the kit is supplied in a real leather wallet and is intended to supplement rather than duplicate your existing tool kit. Thus basic tools like a soldering iron, which it is assumed most constructors will already possess, are not included but less frequently encountered tools like a desoldering gun and cut and bend tool are. With this lot plus your regular tool kit you should be in a position to make and repair just about anything.

Visitors to the show will be invited to place their name and address on a consecutively numbered pad. On Sunday afternoon a winner will be selected using an electronic random number indicator (vicious rumours which claim that we are actually planning to use the circulation figures of rival publications are simply not true — we can't have people squabbling over the lowest numbered sheets!).

Exhibitors at Breadboard will be showing such diverse items as electronic organs, test equipment, books, kits, PCBs, components and much, much more. There will be demonstrations of robots and the opportunity to try out the latest in video games consoles, the CBS Colecovision. This is the game that has taken America by storm and received rave reviews after its appearance at America's largest computer show.

If all the flitting from exciting exhibit to even more exciting exhibit wears you out, you could do worse than to pay a visit to the lecture room. There you will not only have the chance to rest your weary feet but to expand your knowledge at the same time. The complete lecture programme is given below.

Finally, a reminder that the cost of admission to Breadboard will be £2.50 (but watch out for the 50p off vouchers in our ads) and the times are as follows:—

Friday 25th November 10.00-6.00
Saturday 26th November 10.00-6.00

Sunday 27th November 10.00-4.00

Lecture Programme

Friday 25th November
11.00 Electronics in Civil Aircraft Today — F. Ellson-Jones
12.00 Electronic Music — R. Watts
13.00 Soldering — A Neglected Art? — R. I. Cato
14.00 Holography — Practically There — A. Pepper
15.00 Add-ons for Microcomputers — O. Bishop
16.00 Designing and Making Printed Circuits — K. E. Tippey

Saturday 26th November
11.00 Soldering — A Neglected Art? — R. I. Cato
12.00 Electronics in Civil Aircraft Today — F. Ellson-Jones
13.00 Holography — Practically There — A. Pepper
14.00 Add-ons for Microcomputers — O. Bishop
15.00 Electronic Music — R. Watts
16.00 Successful Project Design — A. Armstrong

Sunday 27th November
11.00 Gateway to Electronics — D. Bradshaw
12.00 Add-ons for Microcomputers — O. Bishop
13.00 Designing and Making Printed Circuits — K. E. Tippey
14.00 Electronic Music — R. Watts
15.00 Successful Project Design — A. Armstrong

Autoranging DMM

The new VR-3500 series of hand-held autoranging digital multimeters from Hitachi include temperature measurement among their wide range of functions. Models VR-3510 and VR-3525 have built-in scaling and cold junction compensation for standard K type thermocouples. Surface mounting and protector tube probes working over the range -20 C to +700 C are available from Hitachi, but any K type thermocouple can be used including low-cost bead types.

The VR-3500 series features manual or automatic range selection on voltage and resistance with manual ranging on current from 0.1uA up to 10 amps. Other facilities include a selectable continuity bleeper, a diode test range, and a data hold function. Three models are available with accuracies varying between 0.1% and 0.5%, and all share a common styling with a case which fits easily into the hand.

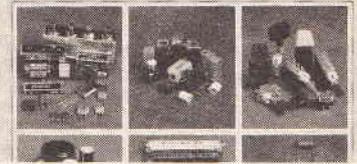
The Hitachi VR-3500 series is available ex-stock from Reltech Instruments and prices start at £82 plus VAT. Reltech Instruments, New Road, St Ives, Cambs, tel 0480 63570.



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Molecular Electronics

Marconi Avionics Limited is to establish a Chair in Molecular Electronics, at the School of Industrial Science, Cranfield Institute of Technology, and to support the research for five years.

Molecular Electronics, a term which was originally used to describe the development of organic materials with useful electrical properties, is now taken to cover a far wider field of materials and processes. One such organic material is polyvinylidene fluoride (PVDF) which, combining the mechanical properties of a plastic and the piezo-electric properties of a crystal, can be used to great advantage in microphones and other pressure-sensitive devices. Many new potential applications for it are already beginning to appear.

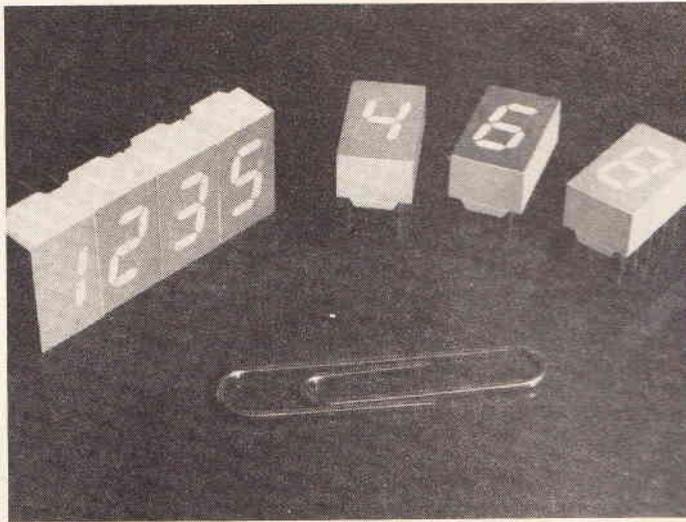
Another important use of molecular material is in electrochromic displays, in which the movement of ions in an electrolyte changes the colour absorption at its surface. These can be developed for a great range of exciting new applications. One such might be as colour liquid crystal displays to replace the monochrome displays which are now in common use in digital watches.

Other fields of known interest at present include new and environmentally-stable materials for use instead of gelatin in new kinds of holographic optics, and germanium, the semiconductor material first used for making transistors and now an important part of modern thermal imaging systems.

250 Watt 30 MHz Transistor

Motorola has introduced the MRF448, a 250 Watt NPN transistor believed to offer the highest power currently available at this frequency. The device is intended for operation in the 30 MHz band with a 50 volt supply and features 14 dB (typ) of gain, 65% efficiency and intermodulation distortion of -33 dB (typ). It is designed primarily for high-voltage applications in high-power linear amplifiers and is said to be ideal for marine and base station equipment.

For further information readers should contact Motorola Ltd., European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP, tel 01-352 041 extn 34.



Mini Seven-Segment Display

A new 0.3 inch (7.6 mm) seven-segment LED display available in standard red, high-efficiency red, yellow and green has been announced by Hewlett-Packard Company. Features such as bright, evenly lit segments, a low forward-drive current, a small, space-saving package and an attractive character front characterise these new HDSP Series displays.

Compared with HP's existing family of 0.3 inch LED displays, this new family requires up to 25% less current and can still be viewed at distances of up to 10 feet (3 metres). Increases of up to 50% in viewed brightness are possible when the displays are driven at typical drive currents of 5 and 10 mA, making them well suited for high ambient-light applications. The display package is 0.3 by 0.5 inches (7.62 by 12.7 mm) and is pin-for-pin compatible with Fairchild's FDN 35X/36X. Details from the Literature Section, Hewlett-Packard Limited, Eskdale Road, Winnersh, Wokingham, Berkshire RG11 5DZ, tel 0734 69662.

Single-Chip CRT Controller

NCR Corporation has introduced a single-chip CRT display controller that can be mask programmed to provide a wide variety of special features and display modes.

Designated the NCR 7250 CRT Controller, it is designed to provide a well-defined interface block between standard microprocessors and microcomputers, and any CRT display. Mixed character and graphic modes, including mosaic and line graphics, are standard features. Nine internal registers are externally addressed to control all display features, including page scrolling, complete cursor-position control, and eight different screen attributes. These include blank screens, reverse video, video chop and enable cursor,

while field attributes include reverse video, blink, blank, video highlight graphics and underline.

The NCR 7250 can be used to display up to 80 x 25 characters with a character cell size of up to 9 x 12. All video signals and up to 240 characters are internally generated, and interleaved CPU access-cycles and auto incrementing address registers give it the ability to update or read a dedicated Video RAM at direct memory access (DMA) rates.

Designed to directly interface with a CRT monitor via the VSYNC and HSYNC outputs, an input clock signal and single RAM are all that is required to produce the video display output. NCR Limited, 206 Marylebone Road, London NW1 6LY, tel 01-388 8244.

High Performance 16 bit ADC

Data Beta have announced a new high-speed analogue-to-digital converter, the ZAD7402, which has a resolution of 16-bits with a relative accuracy of $\pm 0.0015\%$ FSR and a typical conversion time of six microseconds (seven maximum).

Monotonicity is guaranteed and there are no missing codes over the operating temperature range of 0 to 70 C. The converter accepts inputs between +10V and -10V or 0 and 10V and exhibits a differential linearity of ± 0.5 LSB with a temperature coefficient of only 0.8ppm/C. Offset drift is a low 1.5ppm/C and Output codes are binary, offset binary, and twos complement.

Contained in a compact 76 x 117 x 10 mm metal case which gives RFI shielding on six sides, the ZAD7402 runs from +15V

power supplies and consumes approximately 3.5W. Price for 25 off is £670 each and delivery is 4-6 weeks. Data Beta Limited, 23A Buckingham Avenue, Slough, Berkshire SL1 4QA, tel (0753) 7933/4.

Long Wavelength Photo Diode

Hitachi Ltd have developed a new photo diode made of a compound of indium, gallium, arsenide and phosphorus. Employing a PIN structure, the HR1101 is sensitive to light in the wavelength range between 1.0 and 1.5 microns and has a maximum quantum efficiency of about 70%, an indication of its high sensitivity.

Reflecting recent needs for long-distance and large-volume data transmission, the technical trend has been toward the use of the 1.0 and 1.5 micron range where the transmission loss of an optical fibre is at a minimum. In this long wavelength range, the germanium avalanche photo diode has up to now been the only practical choice, but it is not sensitive or fast enough for applications which require higher performance and reliability because its

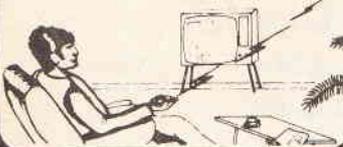
dark current and noise rate are apt to be high and it requires a high supply voltage. The compound employed by Hitachi and the use of a planar structure with a window layer has made it possible to attain high quantum efficiency by protecting the electron-hole pairs generated by photons from disappearing in recombination, and to reduce the electrostatic capacitance, thus improving speed. The HR1101 has a dark current of 7 nA compared with 100-1000 nA for a germanium avalanche photo diode and operates on 5-10 V supplies compared with the germanium device's 30-40 V.

Hitachi says that these technologies help to increase not only the performance and reliability of the HR1101 but also its production yield. Hitachi Electronic Components (UK) Ltd, tel 01-861 1414.

HOME LIGHTING KITS

These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w of lighting

- TDR300K Remote Control Dimmer **£14.30**
- MK6 Transmitter for above **£ 4.20**
- TD300K Touchdimmer **£7.00**
- TS300K Touchswitch **£ 7.00**
- TDE/K Extension kit for 2-way switching for TD300K **£ 2.50**



ELECTRONIC LOCK KIT XK101

This KIT contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to construct a Digital Lock, requiring a 4-key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-wired plug. Size: 7 x 6 x 3 cms. Supply: 5V to 15 V d.c. at 40uA. Output: 750mA max. Hundreds of uses for doors and garages, car anti-theft device, electronic equipment, etc. Will drive most relays direct. Full instructions supplied. **ONLY £10.50**

Electric lock mechanism for use with latch locks and above kit **£13.50**

"OPEN-SESAME"

The XK103 is a general purpose infra red transmitter-receiver with one momentary (normally open) relay contact and two latched transmitter outputs. Designed primarily for controlling motorised garage doors and two auxiliary outputs for drive/garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons. The Kit comprises a mains powered receiver, a four button transmitter, complete with pre drilled box requiring a 9V battery and one opto isolated solid state switch kit for inter-facing the receiver to mains appliances. As with all our kits, full instructions are supplied. **ONLY £23.75**

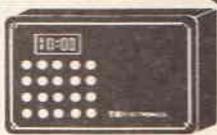
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FEATURES INCLUDE:-

- * 7mm LED 12 hour display
- * Day of week, am pm and output status indicators
- * 4 open collector outputs for driving relays, triacs, etc
- * 50 60Hz mains operation
- * Battery backup saves stored programmes and continues (time keeping during power failures. (Battery not supplied)
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- * Useful 'sleep' function - turns on output for one hour
- * Direct switch control enabling output to be turned on immediately or after a specified time interval
- * 20 function keypad for programme entry
- * Programme verification at the touch of a button
- * Plastic box with attractive screen printed front panel 15 x 10 x 5 cm

Now only **£39.00**

Kit includes all components, PCB, box, assembly and programming instructions. Order as CT6000

XK114 OPTIONAL RELAY KIT Kit includes one relay PCB to accommodate up to four relays, terminal block, and to fit inside CT6000 box. Provides up to four 1amp 240V AC changeover contacts. **£3.90**

Additional relays £1.65 each

CHRISTMAS PRESENTS GALORE

DIGITAL JUMBO CLOCK KIT
This easy to build kit displays the time in 12hr format with flashing colon and pm indication on a large 1.8" LED readout and features an alarm output (sounder required) and countdown timer, making it ideal as a kitchen or office wall clock. **£15.25**

MW RADIO KIT
Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 x 2.7 x 2 cms. Requires PP3 9V battery. **IDEAL FOR BEGINNERS £5.00**

LIGHT DIMMER KIT
Contains all components, including front panel and knob, to make a dimmer for lights up to 300W. **£3.50**

LCD 3 1/2 DIGIT MULTIMETER
16 ranges including DC voltage (200 mv-1000 V) and AC voltage, DC current (200 mA-10 A) gain and diode check. Input impedance 10M. Size 155x88x31 mm. Requires PP3 9v battery. Test leads included. **ONLY £29.00**

3-NOTE DOOR CHIME
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Containing selection of electronic components including transistors, LEDs, diodes, capacitors, ICs etc. together with a descriptive booklet with 10 easy-to-build projects plus a solderless circuit board enabling the components to be re-used. Requires 9V battery. Discreet component pack (no ICs) **£5.00** Integrated circuit pack **£6.00**

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DL 1000K
The value for money kit features a bi-directional sequence speed of sequence and frequency of direction change being variable by means of potentiometers and incorporates a master dimming control. **£14.60**

DL21000K
A lower cost version of the above featuring unidirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. **£8.00**

Optional opto input DL1
Allowing audio ("beat") - light response. **60p**

DL3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built in mic. No connections to speaker or amp required. No knobs to adjust - simply connect to mains supply and lamps (1kw channel) **Only £11.95**



HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains which are decoded by receiver modules connected to the same mains supply and used to switch on the appliance addressed. The transmitter also includes a COMPUTER interface so you can programme your favourite micro (eg ZX81) to switch lights, heating, electric blanket, make your morning coffee etc. automatically without rewiring your house. **JUST THINK OF THE POSSIBILITIES.** The kit includes all PCBs and components for one transmitter and two receivers plus a predrilled box for the transmitter. **Order as XK112. £42.00**

Additional Receivers XK111 **£10.00**

REMOTE CONTROL KITS

FOR A DETAILED BOOKLET ON REMOTE CONTROL - send 30p - 6" x 9" S.A.E. **MK6 SIMPLE INFRA RED TRANSMITTER** Supplied with hand held plastic box. Requires 9V PP3 battery. **£4.20**

MK7 INFRA RED RECEIVER Mains powered with triac output to switch up to 500W at 240V ac. Range approx. 20 ft. on off or momentary control. **£9.00** (RC 500K - special price for MK6 MK7)

MK9 4 WAY KEYBOARD £12.50
For use with MK 16 MK 12 transmitter receiver where only 4 channels are required. **£1.90**

MK10 16 WAY KEYBOARD £5.40
MK11 10 channel - 3 analogue n/p receiver A mains powered LR receiver providing control signals to 10 on/off and 3 analogue circuits. May be used for controlling the volume of an amplifier, brightness of a lamp etc. **£12.00**

MK12 16 CHANNEL LR RECEIVER A mains powered LR receiver providing up to 16 outputs for switching. **£11.95**

MK18 based on the 5L490 This kit includes all components to make a coded transmitter. Requires a PP3 battery and keyboard (MK9, MK10 or MK13 size 8" x 2" x 1.3cm. Range approx. 60 ft.) **£6.20**

MK13 11 way keyboard for use with MK18 and MK11 kits **£4.35**

PE LOGIC TUTOR

A complete kit of top quality components including PCB, connectors, sockets and switches and transformer. **£21.00**
PCB only £4.95

24 HOUR CLOCK/APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains AY 5 1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions. **CT1000K Basic Kit £14.90**
CT1000K with white box (56 131 x 71mm) £17.40
Ready Built - **£22.50**



DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3 1/2 digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required—details supplied), or a sensitive digital thermometer (-50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement—giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week. **Price £15.50**



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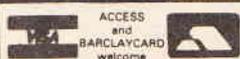
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Reels on Wheels

The latest thing for the 'discerning on-location recorder', so Marantz tell us, is this smart looking portable stereo cassette recorder. Designated the CP430, it and its little brother the CP230 replace the Superscope CD320 and CD330 machines which Marantz have been selling over here for some time.

The two new models are both smaller and lighter than their forbears, offer considerably increased battery life, and have been designed so that no knobs, switches or connectors protrude from the case, affording the maximum protection should they be accidentally dropped. They feature normal, chrome, and metal tape compatibility, fine bias control, speed variable by $\pm 5\%$, memory rewind, illuminated VU meters, and the ability to monitor either channel independently through the built-in loudspeaker. Powering can be by dry batteries, an optional rechargeable battery pack, or from the mains using the adaptor supplied via the 4.5v input jack. Connecting the mains adaptor also charges the battery pack. Line input and output sockets are included so that they can be used with a domestic sound system, mixer etc.

The CP230 is a two head machine with both Dolby B and C noise reduction and costs £169.90 including VAT.

The CP430 has three heads, allowing off-tape monitoring, and has both Dolby B and dbx noise reduction. It costs £249.90 including VAT.

Optional extras include the EM 8 microphone and the RBD430 rechargeable battery pack, both at just under £30 inclusive. Both models come complete with the mains adaptor and a carrying case which incorporates a pocket for the microphone. Marantz Audio UK Ltd, 15-16 Saxon Way Industrial Estate, Moor Lane, Harmondsworth, Middlesex UB7 9LW, tel 01-897 6633.

Videotone Switch

Regular readers will remember that we reviewed the Videotone Minimax 2 speakers back in our September issue. At a press reception recently, they told us that they have already changed the speakers.

The new speakers are still called Minimax 2, although they're now produced in Hungary (the first 2s were made in the UK). The drive units are different, the material of the port is different, the connectors are different — in fact, the whole lot is made by the Videotone company in Hungary, which is a separate entity from Videotone Ltd of the UK.

Videotone claim that the two speakers are very similar indeed, and that any differences are to the favour of the newer version. They certainly sounded OK when driven by the super-fi set-up at the reception — although we didn't get a chance to compare them with the MK1 2s.

Also being launched were two new bookshelf-size speakers, imported from Hungary. The DB1312 is an even smaller two-way system, priced at £49.90 and a three-way system at £99.90 per pair.

To add to this, Videotone will be selling a new budget moving coil high-output cartridge; it's called the MC 88E and sells for £27.90. Also new, is a top-line MC cartridge with a Van den Hul stylus for £114.90, the MC87.

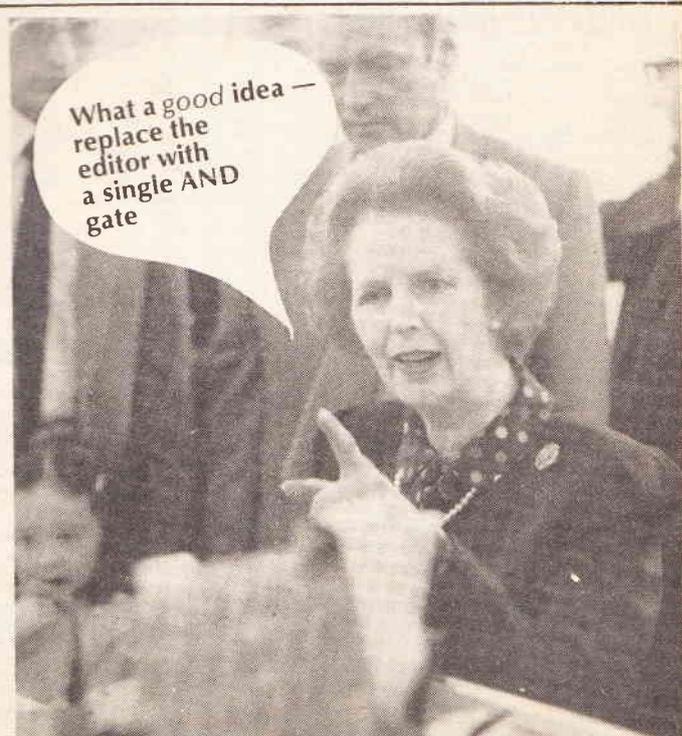
Videotone Ltd, 1st Floor, 55 North Street, Thame, Oxfordshire OX9 3BH; tel 0844-21 6929.

Hall Effect Devices

Following our feature on Hall effect devices in the October issue, a number of companies and individuals have contacted us to ask where the ICs mentioned in the article can be obtained. The short answer is, almost nowhere. There seems to have been so little interest in Hall effect devices in the past that few suppliers have bothered stocking them at all, and those that do rarely offer more than one type. Let us hope that the interest generated by this article will improve matters (advertisers please note!).

So where can you get Hall ICs? Farnell Electronic Components Limited of Canal Road, Leeds LS12 2TU, can supply the UGN3501M but they will only deal with industrial and professional customers. Watford Electronics, who advertise in our pages, can supply a device called the UGN3020T which is similar to the UGN3019T mentioned in the article and comes in the same package. Maplin stock three Hall ICs, two of them switches and one a linear device. None of them were mentioned in the article but you should find enough information in the Maplin catalogue to enable you to use them successfully.

If anyone out there knows of any other suppliers of Hall devices, especially ones who will deal directly with the public and who stock any of the devices mentioned in the article, please let us know and we will give them a mention in a future Digest.



COMTECH ELECTRONICS

TRANSISTORS

BC 1078	12p	BC 546	10p	BF 195	12p	MPSA 55	20p	2N2907A	25p
BC 108C	12p	BC 546B	10p	BF 196	12p	MPSA 56	20p	2N3053	23p
BC 109C	10p	BC 547B	9p	BF 197	12p	MPSA 63	22p	2N3054	56p
BC 113/4	16p	BC 548B	9p	BF 198	10p	MPSA 64	22p	2N3055	50p
BC 115/6	17p	BC 548C	9p	BF 199	12p	MPSA 92	24p	2N3058H	75p
BC 119	28p	BC 549C	9p	BF 200	40p	MPSA 93	24p	2N3440	58p
BC 139	32p	BC 550C	10p	BF 224	15p	TIP 29A	30p	2N3441	120p
BC 140	28p	BC 556	10p	BF 244C	22p	TIP 29B	33p	2N3442	120p
BC 141	29p	BC 556B	10p	BF 245	25p	TIP 29C	33p		
BC 142	27p	BC 557B	9p	BF 256C	32p	TIP 30A	30p	2N3702	10p
BC 143	27p	BC 557C	9p	BF 256LC	35p	TIP 30B	33p	2N3703	10p
BC 160	30p	BC 558B	9p	BF 257	32p	TIP 30C	36p	2N3704	10p
BC 161	32p	BC 558C	9p	BF 258	32p	TIP 31A	33p	2N3705	10p
BC 169C	8p	BC 559C	9p	BF 259	35p	TIP 31B	35p	2N3706	10p
BC 171B	9p	BC 560C	10p	BF 336	36p	TIP 31C	37p	2N3707	10p
BC 172C	9p	BC 637	20p	BF 337	39p	TIP 32A	33p	2N3708	10p
BC 173C	9p	BC 638	20p	BF 338	40p	TIP 32B	35p	2N3771	150p
BC 177B	15p	BC 639	22p	BF 457	32p	TIP 32C	37p	2N3772	170p
BC 178C	15p	BC 640	24p	BF 458	32p	TIP 33A	55p	2N3773	190p
BC 179	15p	BCY 70	18p	BF 459	37p	TIP 34A	60p	2N3819	20p
BC 182	9p	BCY 71	18p	BF 494	12p	TIP 41A	60p	2N3823	50p
BC 182B	9p	BCY 72	17p	BF 595	16p	TIP 41C	60p	2N3866	95p
BC 193B	9p	BD 115	50p	BF 596	20p	TIP 42A	60p	2N3903	10p
BC 193C	9p	BD 131	45p	BFX 29	28p	TIP 42C	60p	2N3904	10p
BC 184B	9p	BD 132	48p	BFX 30	28p	TIP 110	45p	2N3905	10p
BC 184C	9p	BD 133	70p	BFX 84	28p	TIP 115	45p	2N3906	10p
BC 212	9p	BD 135	30p	BFX 85	28p	TIP 120	70p	2N4030	30p
BC 212B	9p	BD 136	30p	BFX 87	27p	TIP 121	70p	2N4033	30p
BC 213B	9p	BD 137	30p	BFX 88	23p	TIP 122	70p	2N4037	40p
BC 213C	9p	BD 138	35p	BFY 50	23p	TIP 126	70p	2N4058	10p
BC 214B	9p	BD 139	35p	BFY 51	22p	TIP 127	70p	2N4059	10p
BC 214C	9p	BD 140	35p	BFY 52	22p	TIP 2955	70p	2N4060	10p
BC 237	7p	BD 203	70p	BSY 95A	23p	TIP 3055	70p	2N4061	10p
BC 238	9p	BD 204	70p	BU 205	140p	TIS 44	20p	2N4062	10p
BC 239	9p	BD 205	70p	BU 206	150p	TIS 90	24p	2N4400	15p
BC 251	9p	BD 206	70p	BU 208	140p	TIS 92	20p	2N4401	15p
BC 300	36p	BD 239A	40p	MJ 2500	230p	2N1613	30p	2N4402	15p
BC 301	32p	BD 239C	50p	MJ 2501	245p	2N1711	30p	2N4403	15p
BC 302	32p	BD 240A	42p	MJ 2955	90p	2N1893	30p	2N4404	15p
BC 303	32p	BD 240C	50p	MJ 3000	210p	2N2218	24p	2N4500	18p
BC 304	32p	BD 241A	42p	MJ 3001	225p	2N2218A	25p	2N4501	20p
BC 307	10p	BD 241C	42p	MJE 340	48p	2N2219	24p	2N4547	28p
BC 308	10p	BD 242A	42p	MJE 350	70p	2N2219A	25p	2N4548	27p
BC 309	10p	BD 242C	54p	MJE 370	80p	2N2221A	20p	2N4549	25p
BC 327	12p	BD 243A	55p	MJE 371	84p	2N2222	18p	2N4580	38p
BC 328	12p	BD 243C	68p	MJE 520	60p	2N2222A	20p	2N4581	18p
BC 337	12p	BD 244A	64p	MJE 521	68p	2N2368	23p	2N4582	20p
BC 338	12p	BD 244C	78p	MJE 525	80p	2N2369A	15p	2N4602	23p
BC 413C	10p	BF 180	30p	MJE 3055	68p	2N2484	24p		
BC 414C	10p	BF 181	30p	MPSA 05	20p	2N2646	48p		
BC 415C	10p	BF 182	30p	MPSA 06	20p	2N2904	22p		
BC 416C	10p	BF 183	30p	MPSA 12	22p	2N2904A	23p		
BC 477	25p	BF 184	30p	MPSA 13	22p	2N2905	23p		
BC 478	23p	BF 185	30p	MPSA 42	23p	2N2906A	23p		
BC 479	24p	BF 194	12p	MPSA 43	23p	2N2907	23p		

THYRISTORS

C106D	28p	4000	14p
C116D	70p	4001	14p
C126D	90p	4002	14p
C126M	98p	4006	50p
MCR 101	30p	4007	16p
MCR 102	34p	4008	50p
T 2800D	110p	4011	14p
T 2800M	165p	4012	15p
2N4443	130p	4013	24p
2N4444	120p	4014	24p
2N5060	23p	4015	46p
2N5061	24p	4016	24p
2N5062	29p	4017	42p
2N5064	32p	4018	47p
		4019	30p
		4020	46p
		4021	42p
		4022	46p
		4023	14p
		4024	38p
		4025	14p
		4026	84p
		4027	29p
		4028	42p
		4029	48p
		4030	18p

CMOS

W005	18p	4035	56p
W01	20p	4040	48p
W02	22p	4041	48p
W04	24p	4042	42p
W06	28p	4043	44p
W08	32p	4044	44p
3A/50V	40p	4046	55p
3A/100V	42p	4048	30p
3A/200V	44p	4049	25p
3A/400V	46p	4050	25p
6A/50V	75p	4051	52p
6A/100V	80p	4052	52p
6A/200V	86p	4053	54p
6A/400V	94p	4056	28p
25A/100V/185p		4068	15p
25A/200V/198p		4069	15p
25A/400V/220p		4070	15p
		4071	15p
		4072	15p
		4073	15p
		4074	15p
		4075	15p
		4077	15p
		4078	15p
		4081	15p
		4082	15p
		4093	32p
		4098	78p
		40161	52p

CPU IC's

40162	52p	6800	395p
40163	52p	6802	550p
4501	16p	6808	520p
4502	15p	6810	250p
4503	34p	6820	250p
4504	98p	6821	190p
4506	70p	6840	595p
4508	145p	6850	180p
4510	50p	6852	360p
4511	52p	6880	140p
4512	48p	6885	130p
4513	98p	6889	140p
4514	110p	6800 POA	
4516	55p	8726A	140p
4517	180p	8728	120p
4518	52p	8795	140p
4520	55p	8797	140p
4522	65p	8798	140p
4526	64p	8080A	400p
4528	56p	8085A	500p
4529	72p	8156C	600p
4530	92p	8212C	198p
4531	70p	8216C	140p
4532	88p	8224C	220p
4541	70p	8228C	450p
4544	120p	8251AC	495p
4551	88p	8253AC	800p
4553	180p	8257C	750p
4554	148p	8259C	910p
4555	48p	8288	£6
4556	48p	TMS9980A£22	
4557	160p	TMS9981E£25	
4558	110p	TMS9901N590p	
4559	390p	TMS9902N590p	
4560	170p	Z80A 4M 380p	
4566	120p	Z80A PI0350p	
4568	270p	Z80A DMA £25	
4569	140p	Z1014A 300p	
4572	42p	Z114 120p	
4573	198p	Z147-70S 600p	
4574	198p	Z147-4S 700p	
4575	198p	Z147-5S 700p	
4580	280p	Z147-6S £10	
4584	38p	4016-200S £7	
4585	74p	5101LC 340p	
4589	178p	5101LC-1395p	

VOLTAGE REGULATORS

100mA	
100mA	30p
78L05	30p
78L12	30p
78L15	30p
78L18	45p
78L24	45p
1 A TO220	
7805	36p
7808	55p
7812	36p
7815	36p
7818	36p
7824	40p
5 A TO3	
78H05	500p
Negative	
100 mA	
79L05	50p
79L12	50p
79L15	50p
1 A TO220	
7905	45p
7906	65p
7908	65p
7912	55p
7915	55p
7924	65p

BRIDGE RECTIFIERS

W005	18p	4035	56p
W01	20p	4040	48p
W02	22p	4041	48p
W04	24p	4042	42p
W06	28p	4043	44p
W08	32p	4044	44p
3A/50V	40p	4046	55p
3A/100V	42p	4048	30p
3A/200V	44p	4049	25p
3A/400V	46p	4050	25p
6A/50V	75p	4051	52p
6A/100V	80p	4052	52p
6A/200V	86p	4053	54p
6A/400V	94p	4056	28p
25A/100V/185p		4068	15p
25A/200V/198p		4069	15p
25A/400V/220p		4070	15p
		4071	15p
		4072	15p
		4073	15p
		4074	15p
		4075	15p
		4077	15p
		4078	15p
		4081	15p
		4082	15p
		4093	32p
		4098	78p
		40161	52p

LED'S

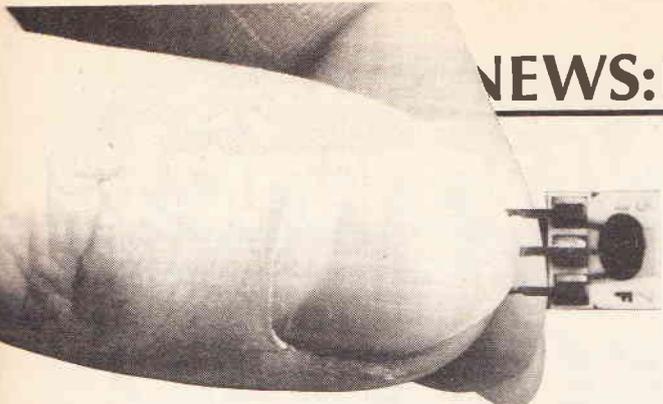
3mm red	7p
5mm red	7p
3mm green	10p
5mm green	10p
3mm yellow	10p
5mm yellow	10p
clips	3p
rectangular	
Red	10p
Green	14p
Yellow	14p

IC SOCKETS

8 pin	7p	28 pin	16p
14 pin	8p	40 pin	20p
16 pin	9p	SPECIAL OFFERS	20p
18 pin	11p	25 x 22 pin	27p
20 pin	14p	25 x 28 pin	340p
22 pin	14p	10 x 40 pin	185p
24 pin	16p	25 x 40 pin	440p

OPTO

TIL 32	55p
TIL 38	40p
TIL 78	50p
TIL 100	100p
TIL 111	85p
2N5777	50p
4N25	80p
4N33	128p
4N35	150p
4N37	100p
BPX 38	390p
BPX 33	340p
TIL 221	20p



Miniature Position Sensor

Honeywell has introduced a low cost version of its smallest, ceramic-packaged, Hall effect sensor. Consisting of an epoxy-coated IC mounted on a 7.6 mm ceramic square, the 8SS has a temperature range from 0 to 50°C making it ideal for room temperature applications.

The 8SS has a two-state digital output and responds to variations in magnetic field, generated by approach and withdrawal of an external magnet. Small size and an operating frequency of 100 kHz make it extremely versatile. Applications include sensing of cam position, ignition timing, potentiometers, tachometers and

wherever a miniature sensor is needed. A linear output version is also available.

8SS devices are available for two voltage ranges: 4.5 to 5.5 V DC and 6 to 16 V DC, and output is either bipolar or unipolar current sink. Maximum operate magnetic field is +0.0025T Tesla, minimum release is -0.025T, and minimum differential is 0.004. Mounting and package options available include lead wires, solder pads only or variations on the standard PCB termination pins. The corners of the ceramic can be cropped to reduce the size of the package where space is at a premium.

SHORTS

● A note of gloom to start the winter on. Business information company Dun & Bradstreet Ltd inform us that 562 electrical companies went into liquidation during the first nine months of this year, an increase of 11.5% over the same period last year. There were 72 bankruptcies in the industry in the same period and this represents a 9% increase on last year's figure.

● Have you been ripped-off? Inmac's new sprocket-hole reinforcing tape will repair damaged computer printout as well as protecting undamaged printout. Made of tough clear vinyl, it is simply cut to length and the pre-punched holes aligned with those of the printout. Further information can be found in the free, full colour catalogue which is available from Inmac (UK) Ltd, Davy Road, Astmoor, Runcorn, Cheshire WA7 1QF, tel 09285 67551.

● Lloyd's Register of Shipping have produced a unique English/Japanese dictionary of technical terms. Although aimed primarily at the shipbuilding industry, it covers a wide range with 5000 entries in 192 pages, and best of all, it's free. Lloyd's Register of Shipping, 71 Fenchurch Street, London EC3M 4BS, tel 01-709 9166.

● K.E. Developments have produced a range of printed circuit mounting DC-DC converters which offer a choice of regulated

and un-regulated fully isolated outputs from standard 5 and 12 volt inputs. The converters are available in 2.5 and 6 watt versions with efficiencies of 50% and 70% respectively and with outputs of $\pm 5V$, $\pm 12V$, $\pm 35V$, $+180V$, and $+240V$. K.E. Developments Ltd, The Mount, Toft, Cambridge CB3 7RL, tel 022 026 3532.

● Another useful address for everyone out there with a mutilated multimeter. Aughton Automation Ltd of 29 Woodward Road, Kirby Industrial Estate, Liverpool L33 7UZ, can repair and re-calibrate most electrical and electro-mechanical test equipment. Their telephone number is 051 548 6060.

● Bring your Sinclair up to date with Glanmire Electronics' new Time Controller. Consisting of a battery backed up real time clock, it provides the computer with month, day, date, hours, minutes, and seconds and has eight programmable inputs and eight programmable outputs and an extension for the attachment of further peripherals. Available for the ZX81 at £34.50 and for the Spectrum at £38.50 direct from Glanmire Electronics Ltd, Westley House, Trinity Avenue, Bush Hill Park, Enfield EN1 1PH, tel 01-366 3245.

● Toolrange's Combi-Check is a hand-held combined voltage and continuity tester. It detects the presence of 6, 12, 24, 50, 110, 220, 380, and 660 V DC or up to 100 Hz AC, displaying the result on a row of LEDs, and will make

Marconi Spins a New Yarn

Marconi Space & Defence Systems Limited has developed a novel solution to the problems traditionally encountered in producing electrical cable harnesses. Such work has previously been carried out on a peg board and has been time-consuming and labour intensive.

The solution and the product, 'Marconiweave', is based on a unique adaptation of standard weaving machinery, and can meet the requirements for quality and reliability imposed by military standards. 'Marconiweave' allows a user to specify hybrid woven cables combining different types of construction — flat, multilayer and tubular — and to combine a wide range of different wire gauges and insulation factors. Many kinds of multicore cable may be specified including screened varieties, and any length can be woven into a flat cable-form. The fact that 'Mar-

coniweave, can also be woven in the form of a tube allows extra wires to pass through the centre and to accommodate other services such as small tubes carrying liquids or gases. Tubes and optical fibres can also be combined with wires in a flat ribbon and spacers can be inserted automatically to maintain a constant and controllable distance between wires.

Applications for 'Marconiweave' are foreseen in many areas of communications, especially those where the position of each wire relative to every other wire must be held constant. Further applications exist in the fields of computers, test equipment and many other installations involving large numbers of electrical connections. Marconi Space & Defence Systems Limited, West Avenue, Kidsgrove, Staffordshire, tel 07816 3501.

Chambers, Shelton Square, Coventry, tel 0203 27259.

● National Panasonic have introduced three new sizes of 3V Lithium - Polycarbonmonofluoride batteries to their range for use in memory support and long-life standby applications. New sizes are 2/3 AAA with 300 mAh capacity (10.5 mm dia x 30 mm) and A size with 1.9 Ah capacity (17 mm dia. x 41.4 mm). Cells are available with either solder tags or pins and have a shelf life in excess of 10 years. Special Batteries Division, Panasonic Industrial (UK) Ltd, 300-318 Bath Road, Slough, Berkshire SL1 6JB, tel 0753 34522.

● The Open Computing School offers courses in everything from beginners BASIC to the more sophisticated information retrieval systems. Courses are self-paced and students can choose their hours of attendance. A 15 hour BASIC course costs £45. Details from Jack Flatau, Polytechnic of the South Bank, Borough Road, London SE1 0AA, tel 01-928 8989 extension 2468.

● Cumana have introduced a new 5 1/4" disc drive for the BBC and Dragon microcomputers which will be sold through High Street outlets such as W.H. Smiths. The drives have their own power supply, are available in 40 and 80 track single sided and 80 track double sided versions, and come with a 12 month guarantee. Two drive can be used simultaneously with the BBC and up to four with the Dragon.

polarity and continuity tests at up to about 2M ohms. Operating from a 12V battery and with an input resistance of 660k, the Combi-Check is available from Toolrange Ltd, Upton Road, Reading, Berkshire RG3 4JA, tel 0734 29446.

● The Institution of Electrical Engineers are to hold a one-day colloquium on 'Techniques of Medical Imaging'. It will take place on Wednesday 23rd November at the IEE headquarters at Savoy Place and will cost non-members £33.35 plus lunch. The IEE, Savoy Place, London WC2R 0BL, tel 01-240 1871.

● Thorn EMI Electron Tubes Ltd have published a paper called "Voltage Divider Design" which deals with design of divider networks for use with photomultiplier tubes. The paper covers such requirements as linearity, scintillation counting, speed of response, etc, and is available free from Thorn EMI Electron Tubes Ltd, Bury Street, Ruislip, Middlesex HA4 7TA, tel 08956 30771.

● The PBL 3747 monolithic IC is designed to solve matching problems wherever a high impedance source must be fed into a low impedance load. Incorporated in a TO-92 plastic package, the device has an output impedance of 60 ohms, an input impedance of 66M ohms, 1% distortion at its maximum output of 200 mV, and 2.5 dB gain at 1000 HZ. Contact RIFA AB, Market

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 OR { 1 x 600W into 2 to 8Ω
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- Etc. Etc.

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	75189 0.37	
	75451 0.22	
	75452 0.22	
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	75454 0.22	
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	MC3446 D1 2.50	
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2532 450NS D2 3.45	8251A D5 2.50
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2732 350NS D1 5.45	8255A D5 2.25
2764 300NS D1 7.95	
4116 150NS D1 0.85	
4116 200NS D2 0.80	
4118 150NS D1 3.25	
5516 200NS D2 9.45	
6116 150NS D1 3.30	
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14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
28	24	55	80
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TL091 0.40	
TL092 0.58	
TL094 1.34	
TL487 0.62	
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ETI

16 CHANNEL A/D CONVERTER

Get your micro to do some real work with the aid of our versatile unit. Design by Bob Campbell.

Connecting one's micro to the outside world is probably one of the most rewarding and exciting computing projects that you can undertake. Not only that but it is often extremely useful — a carefully designed central heating control system could save you enough money to pay for the project itself!

To link the digital world of the micro to the real world of analogue signals an interface is required. The interface is used either to turn a digital signal into some meaningful voltage or current, or to convert a voltage into a digital signal so that the computer can interpret it. The digital to analogue converter side of things was more than adequately covered in the March issue of ETI, so this article will present the other side of the coin, the analogue to digital converter. As with the previous project, this design is based on the Tangerine Micron Microtan 65 system, but consideration has been given to the question of adapting the design to suit other systems, including Z80 based computers.

The circuit is designed around the industry standard ADC0808 or ADC0809, both of which are 8 bit, 8 channel, microprocessor compatible analogue to digital converters. The difference between the 0809 and 0808 is the accuracy, being ± 1 LSB and $\pm \frac{1}{2}$ LSB respectively. The converter is a CMOS device made by National Semiconductor amongst others, and uses a conversion technique known as successive approximation. This technique usually provides fast conversion times, together with good overall accuracy. Other features of this converter are single supply operation, no zero or full scale adjustments re-

quired, low power, and guaranteed monotonicity. This last point can be very important, particularly in high speed closed loop feedback systems. Non-monotonicity in such situations would produce oscillation, which could be catastrophic for the system being controlled.

The main conversion elements of the 0808 are a high impedance, chopper stabilised comparator, a 256R voltage divider network and an analogue switch tree, together with the all important successive approximation register. In front of the converter is an 8 channel analogue multiplexer controlled by a 3 bit address latch, giving the converter access to any one of eight single-ended analogue signals. Figure 1 shows the internal block diagram of the converter.

The circuit is designed on the

International-size card to suit the Microtan, and includes provision for two converters giving a maximum of 16 channels. The remainder of the circuitry consists of the data bus buffers and address decoding, and IC3 which is used to convert $\overline{O2}$ and the R/W line into NRS and NWS (NOT READ STROBE and NOT WRITE STROBE). Processors like the Z80 already have these as \overline{RD} and \overline{WR} , and thus do not require IC3 to be fitted.

The decoding section is very similar to that used in all other recent Microtan designs. IO is the only non-standard signal, and this is decoded with A3-A9 inclusive to produce 128 eight byte addresses, any 8 of the 128 being available at any one time. The remaining three address lines A0 to A2 are used to

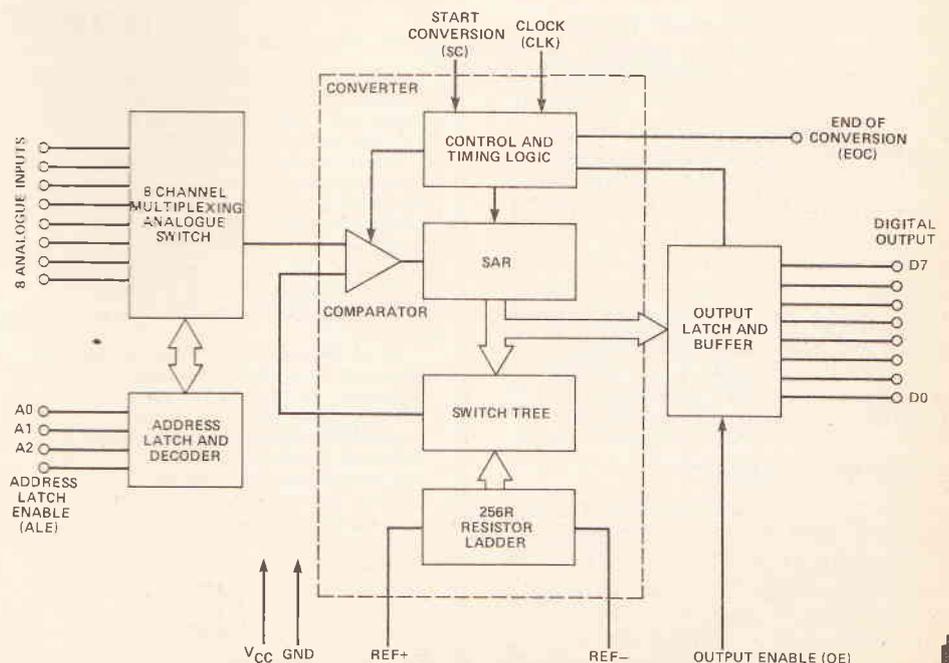


Fig. 1 Internal block diagram of the ADC0808.

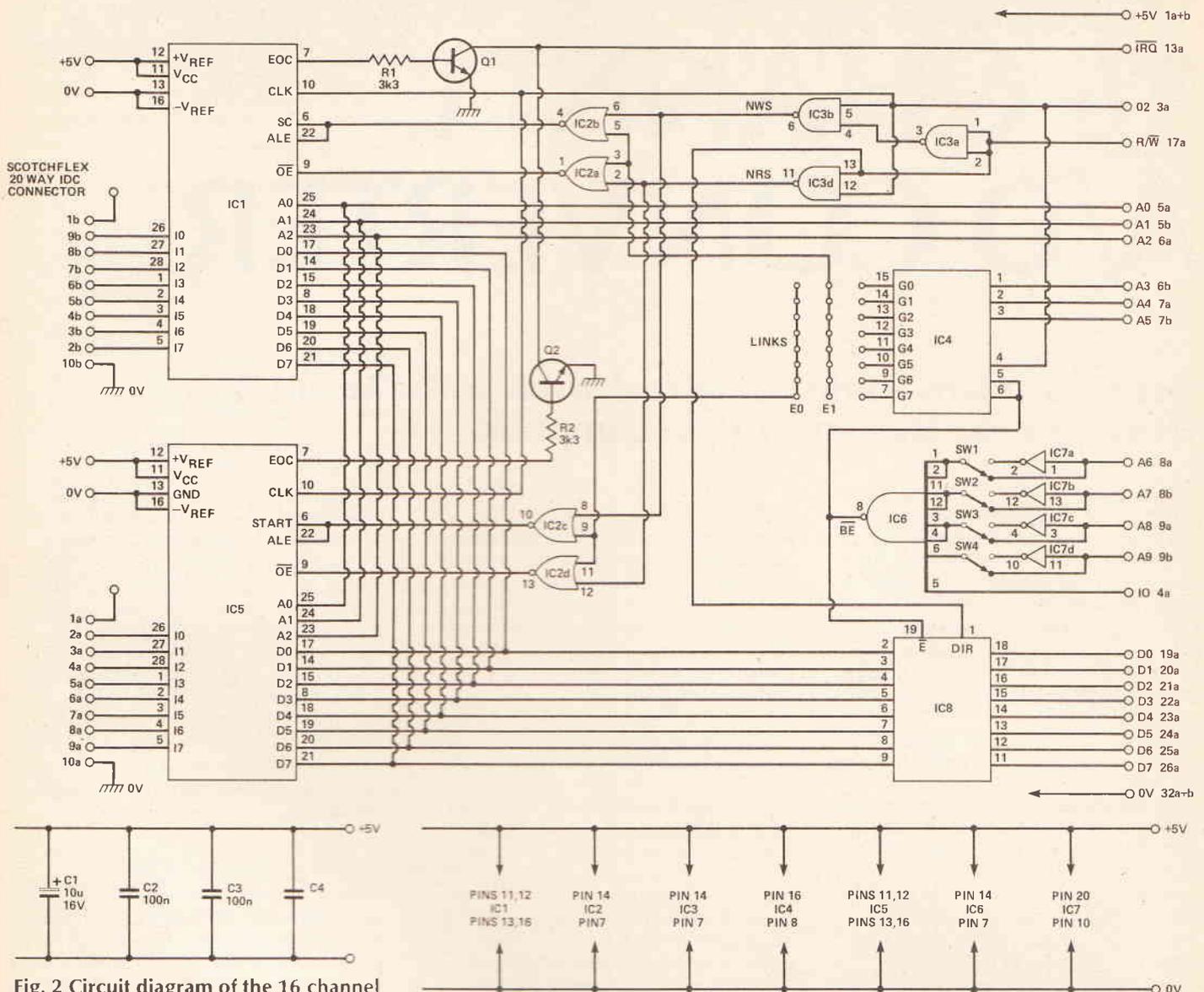


Fig. 2 Circuit diagram of the 16 channel A/D converter.

select the input channel for the converter. Setting the address of each converter is accomplished with DIL switches SW1-4 and with links between G0-G7 and E0, E1. SW1-4 set up the overall addresses of the 8, eight byte blocks and the links are used to select the individual block of each converter within the overall address. For example, setting SW1-4 to 1, E0, to G., and E1 to G1 will give us an address block 16 bytes long, BC00 to BC07 for IC1 and BC08-BC0F for IC5 (48128 to 48135 and 48136 to 48143 inclusive.)

Construction

Before commencing construction you should decide which of the various circuit options you wish to include. IC3 may not be needed depending upon the micro-processor you are working with, and R1, R2, Q1, and Q2 will

HOW IT WORKS

Since the operation of the circuit is quite well covered in the section on programming and elsewhere, we will devote this section to the ADC0808/9 itself.

There are three main elements to the converter, the successive approximation register (SAR), the comparator and the resistor ladder-switch tree array. In addition there is a 1 of 8 analogue multiplexer to select the input signal, timing and control logic, and tristate data buffers, which as a whole form the data acquisition circuit.

The SAR is reset on the positive edge of the start conversion pulse, and if another SC signal is applied during an incomplete conversion the current conversion will be aborted in favour of the new request. Continuous conversion cycles can be obtained by tying the end of conversion (EOC) output to the SC input.

The analogue signal, 1 of 8 selected by the multiplexer, is fed through to the comparator. This comparator is responsible for the accuracy and repeatability of the converter and the 0808/9 uses a chopper stabilized technique to achieve

the specified stability and accuracy. The other output to the comparator is from the switch tree and is equivalent to the previous approximation to the input signal. The comparator first converts the DC input signal to an AC signal then boosts this through a high gain AC amplifier before restoring the DC level. Thus any DC drift component of the input signal is filtered out at this stage, prior to the actual conversion taking place.

The output of the comparator is then fed to the SAR which in turn controls the next output from the switch tree. Thus on each successive iteration the output of the switch tree is fed back via the comparator to the SAR to form the next iteration. On the eighth iteration the output will be within 1/2 LSB of the ideal value.

Data is then available at the outputs, after taking OE low. Overall timing of the conversion is controlled directly by the clock input, which should be between a minimum of 10KHz and 1.28MHz maximum.

PROJECT : 16 Channel A/D Converter

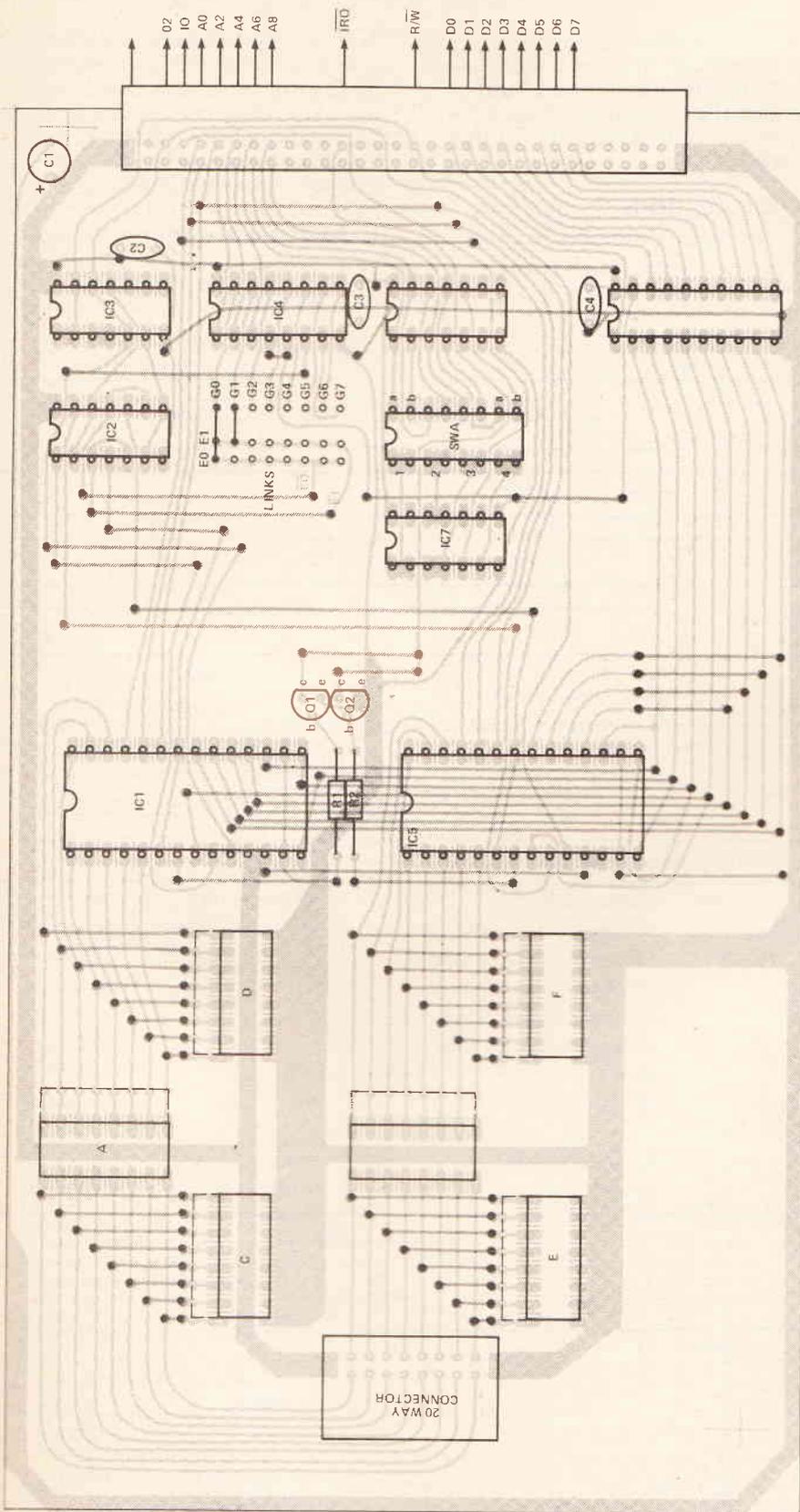


Fig. 3 Component overlay of the PCB. The blocks marked A, B, C, D, E, and F are positions where input filter components may be inserted. If none are used, links should be inserted in positions A and B.

not be needed if you plan to use interrupt driven routines. Provision has been made for the inclusion of various input filter and attenuator components on the board, and if none is used you will have to insert links in their place. The standard arrangement is a simple 1k series resistor but a number of possibilities exist and a few examples are given in Fig. 4. Since every application is different it is not possible to cover every requirement, and you may find it necessary to experiment a little here.

As with previous projects, a double sided board has been used but without plated through holes. This helps to keep the cost down, but it does mean that a lot more care has to be taken in the construction. The positions of the through board links are shown on the component overlay drawing, Fig. 3. Sockets have been specified for all the ICs and should certainly be used for the A/D converters at least because these are CMOS. The DIL switch could, of course, be replaced with wire links, and whilst the switches are preferable they are certainly not cheap.

With the assembly complete, the next stage is the programming. To initiate a conversion of a specific analogue channel a write operation on that address must be performed. This could be, for

PARTS LIST

Resistors	
R1, 2	3k3 ¼W 10% (see text)
Capacitors	
C1	10u 16V radial
C2, 3, 4	100n ceramic
Semiconductors	
IC1, 5	ADC0808 or ADC-0809 (see text)
IC2	74LS02
IC3	74LS00 (see text)
IC4	74LS138
IC6	74LS30
IC7	74LS04
IC8	74LS245
Q1, 2	BC184, BC109 etc (see text)
Miscellaneous	
DIN 41612 64 way indirect edge connector; 20 way male PCB header and matching IDC socket; PCB; 4 x 14 pin DIL sockets, 1 16 pin, 1 20 pin, and 2 x 28 pin sockets; DIL switch, quad SPDT; ribbon cable, input filter components, etc.	

BUYLINES

Technomatic can supply the ADC0808 and the DIN indirect edge connector, and the 20 way IDC connectors are available from Ambit. Nothing else should cause any problems, and the PCB is available through our PCB service, see page 74.

example, POKE 48128,0 in BASIC or STA BC00 in assembler. This latches the address and pulses the SC input via IC2 starting the conversion on that channel. Assuming for the moment that the system clock used is 750 kHz and that the EOC link has been omitted, then we must wait for 80 μ s before the converted data is available on the data bus. It is a simple matter then to read from the same address as before to obtain that data. For example DATA = PEEK (48128) or LDA BC00. The OR gate IC2 makes sure the decoded signal E0 or E1 and the NRS (RD) are both low before pulsing the OE input of the converter and enabling the tristate buffers. In fact on the authors system the time delay associated with BASIC means that PEEKing immediately after POKEing the required channel address works well, eg

```

10 POKE AD, 0
20 DATA = PEEK (AD)
30 PRINT DA
40 GO TO 10

```

By connecting the EOC link the need for the time delay routine can be avoided. In this case the EOC signal is used to pull the TRQ line low on the processor causing an interrupt, which must be handled in the normal manner with an interrupt service routine. Such a routine is difficult to implement in BASIC but is very simple in machine code or assembler. One particular point to note if using this technique is the EOC delay time, which is the delay before EOC is

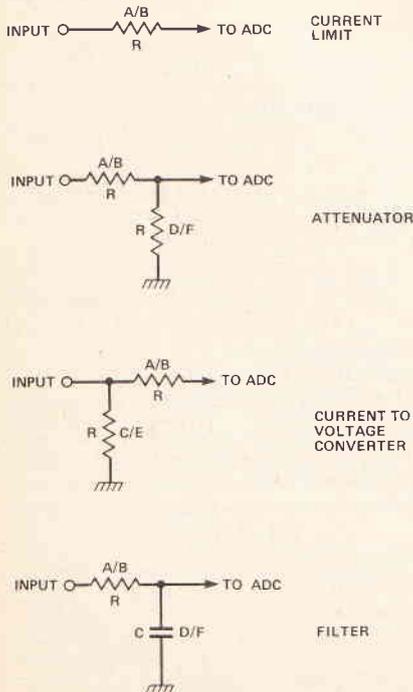


Fig. 4 Input circuit arrangements.

reset after a new SC signal is sent. It is important therefore that interrupts are not enabled before this time has elapsed. Figure 5 shows the timing diagram for the converter.

Applications

The most common use of an

A/D converter is simply to measure a voltage generated or controlled by the equipment under observation. The voltage transducer may be anything from a strain gauge amplifier to something as simple as a variable resistor acting as a potential divider. This latter case is an example of a ratiometric type

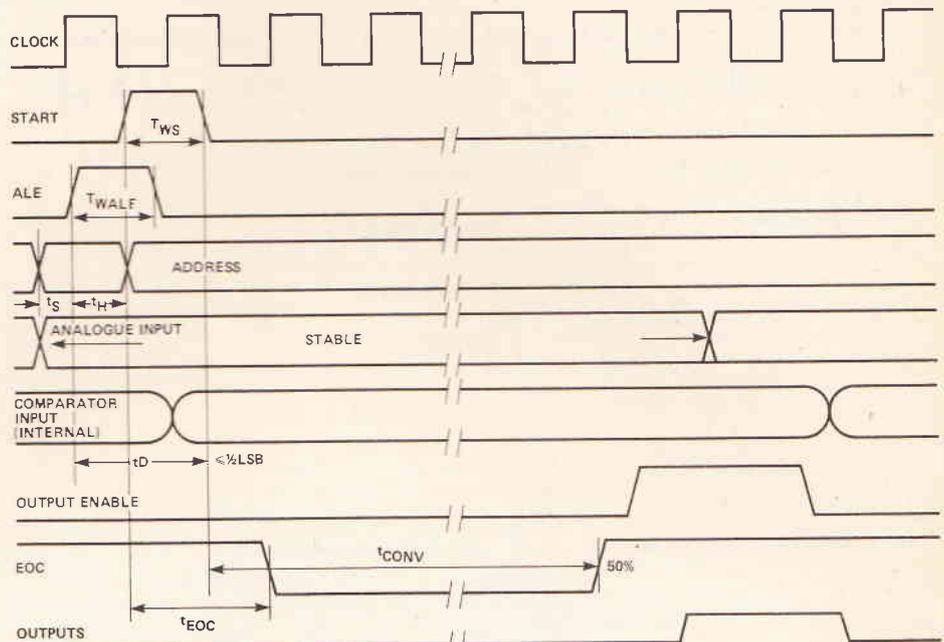


Fig. 5 Timing diagram for the ADC0808.

SYMBOL	PARAMETER	MIN	TYP	MAX
T_{WS}	Minimum Start Pulse Width		100ns	200ns
T_{WALE}	Minimum ALE Pulse Width		100ns	200ns
t_s	Min Address Set-Up time		25ns	50ns
t_h	Min Address Hold Time		25ns	50ns
t_D	Analog MUX Delay Time from ALE		1us	2.5us
t_{EOC}	EOC Delay Time	0		8 clock cyc + 2.0 us
t_{CONV}	Conversion time	90us	100us	116us
f_c	Clock Frequency	10kHz	640kHz	1280kHz

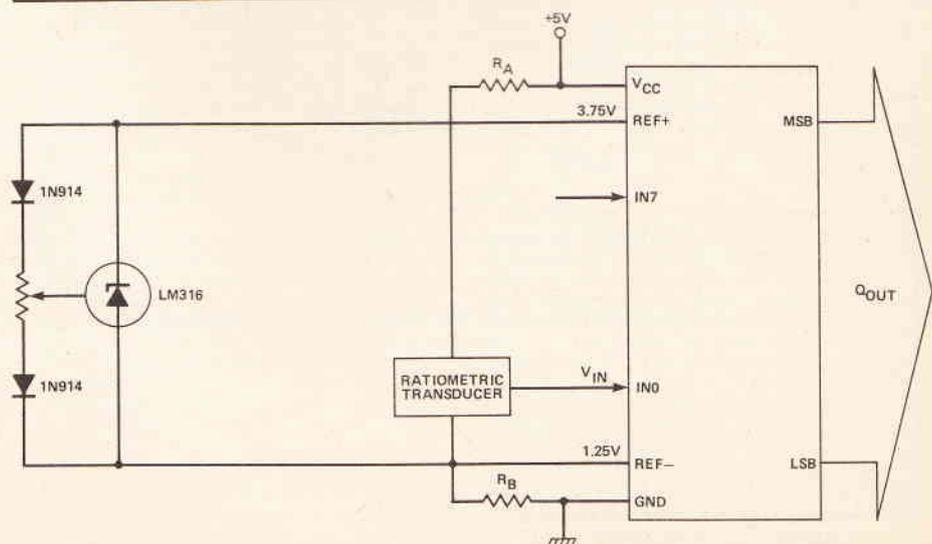


Fig. 6 Ratiometric conversion

PROJECT : 16 Channel A/D Converter

of transducer, where the input being measured is expressed as a percentage of full scale which is not necessarily related to any absolute standard. This type of transducer has several advantages, particularly in low cost systems since the need for a highly stable and accurate reference voltage is reduced, often to the point where

the supply voltage itself is more than adequate.

The ratiometric conversion technique equation is

$$\frac{V_{in}}{V_{fs} - V_z} = \frac{D_x}{D_{max} - D_{min}}$$

where

V_{in} = input voltage into the ADC0808

V_{fs} = full scale voltage

V_z = zero voltage

D_x = data point being measured

D_{max} = maximum data limit

D_{min} = minimum data limit

Applying this equation to the potentiometer example shown in Fig. 6 we get

$$Q_{out} = \frac{V_{in}}{V_{ref}} = \frac{V_{in}}{V_{cc}}$$

where $4.75V V_{cc} = V_{ref}$ $5.25V$ and the Q_{out} is the 8 bit digital output.

The most obvious example of a use for the potentiometer as a transducer is a position encoder, which could be a joystick or a rotary shaft encoder on a robot axis motor. In fact the uses for such a transducer are almost endless and similar ratiometric transducers include thermistor bridges, pressure transducers, etc.

Some applications require the measure to be made with reference to an absolute standard voltage or current. There are two widely used methods of reference conversion, ground referenced and centre referenced. In each case there are numerous ways of producing the supply and reference voltages, and examples are shown in Figs. 7 and 8.

Z80 Conversion Notes

As mentioned in the introduction, the modifications necessary for the Z80 processor are very straight-forward. IC3 can be omitted and the RD and WR lines directly substituted for NRS and NWS. There are no write operations involving data valid for this board, and FIR on IC9 (pin 1) should be connected to an inverted RD or taken permanently high.

A0 to A7 inclusive are identical but in the Z80 case must be used with the IOREQ line to decode an output address. The simplest way to achieve this is to substitute A0 - A7 directly, IOREQ for A8, and tie A9 and 10 permanently high. This obviously means SW4 must always be in position 2, and SW3 in position 1. The master clock, pin 10 on IC1 and IC5 should be taken to any TTL clock of a suitable frequency i.e. between 10 KHz and 1.2 MHz. A 4 MHz system clock divided by four with the aid of a 74LS74 would prove suitable.

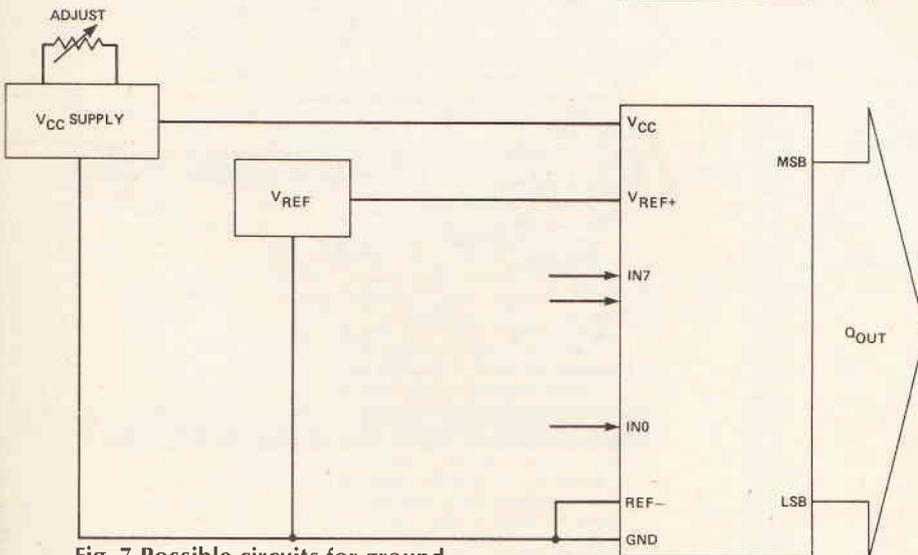
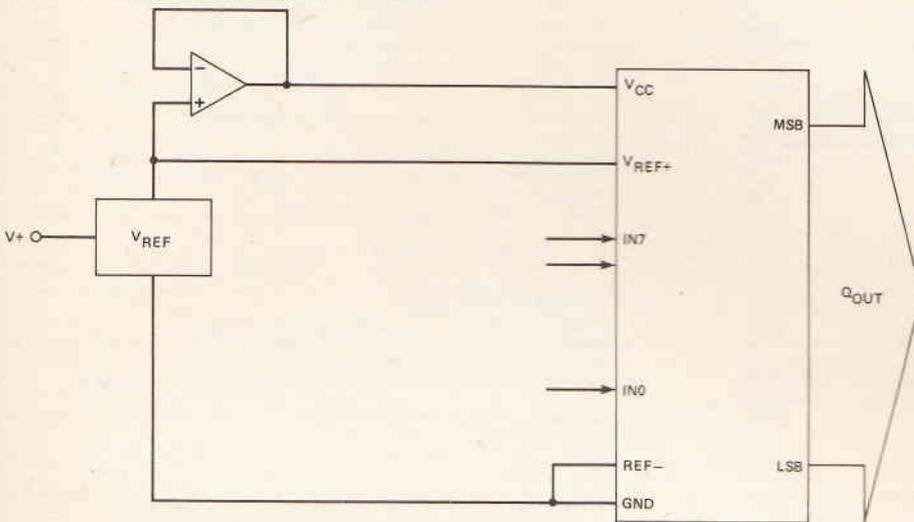


Fig. 7 Possible circuits for ground referenced systems.

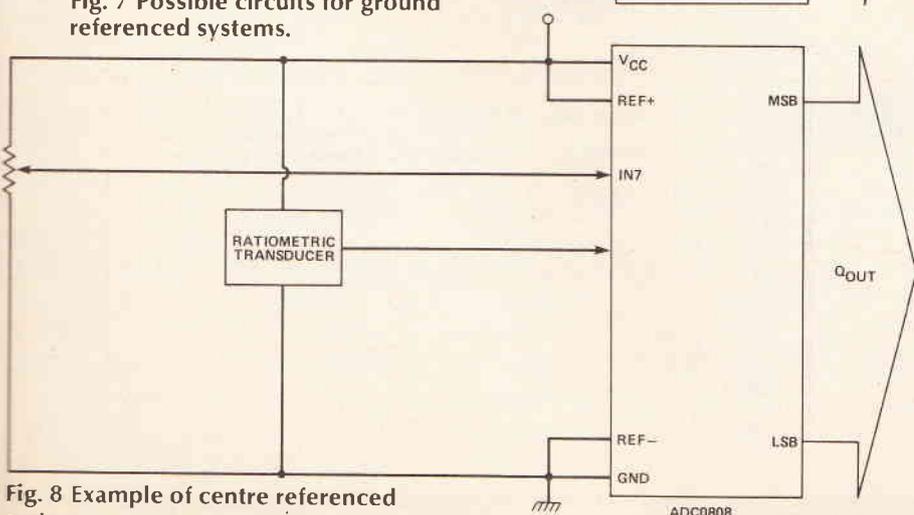


Fig. 8 Example of centre referenced system.

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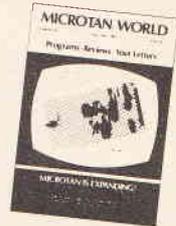
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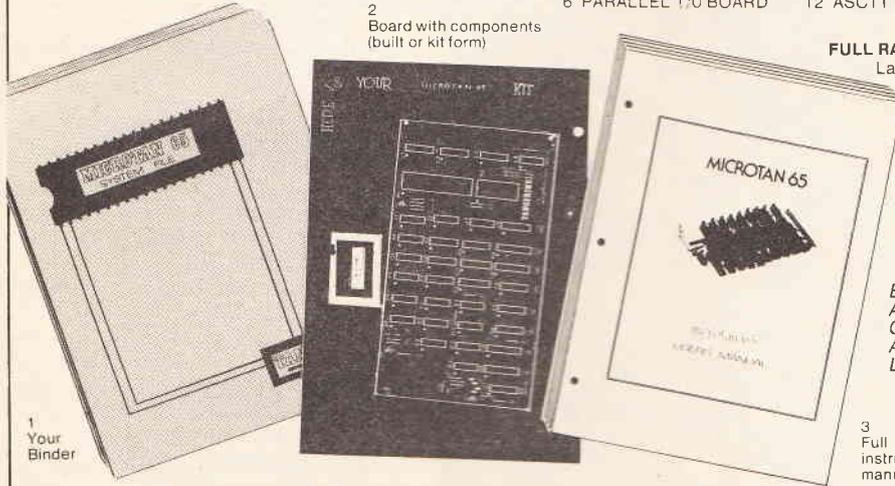
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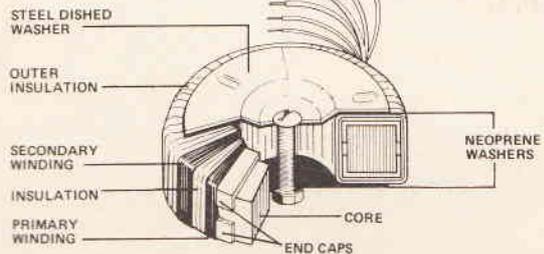
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No	Volts Current	2x011 9+9 2.77	4x011 9+9 6.66	8x013 15+15 7.50	8x014 18+18 6.25	8x015 22+22 5.11	8x016 25+25 4.30	8x017 30+30 3.75	8x018 35+35 3.21
0x010	6+6 1.25	2x012 12+12 2.08	4x012 12+12 5.00	8x015 22+22 5.11	8x016 25+25 4.30	8x017 30+30 3.75	8x018 35+35 3.21	8x019 40+40 2.81	8x020 45+45 2.50
0x011	9+9 0.83	2x013 15+15 1.66	4x013 15+15 4.00	8x017 30+30 3.75	8x018 35+35 3.21	8x019 40+40 2.81	8x020 45+45 2.50	8x021 50+50 2.25	8x022 55+55 2.04
0x012	12+12 0.63	2x014 18+18 1.38	4x014 18+18 3.33	8x019 40+40 2.81	8x020 45+45 2.50	8x021 50+50 2.25	8x022 55+55 2.04	8x023 60+60 1.82	8x024 65+65 1.64
0x013	15+15 0.50	2x015 22+22 1.13	4x015 22+22 2.72	8x022 55+55 2.04	8x023 60+60 1.82	8x024 65+65 1.64	8x025 70+70 1.46	8x026 75+75 1.32	8x027 80+80 1.19
0x014	18+18 0.42	2x016 25+25 1.00	4x016 25+25 2.40	8x026 70+70 1.46	8x027 80+80 1.19	8x028 85+85 1.07	8x029 90+90 0.96	8x030 95+95 0.86	8x031 100+100 0.77
0x015	22+22 0.34	2x017 30+30 0.83	4x017 30+30 2.06	8x028 85+85 1.07	8x029 90+90 0.96	8x030 95+95 0.86	8x031 100+100 0.77	8x032 110+110 0.69	8x033 120+120 0.62
0x016	25+25 0.30	2x018 36+36 0.71	4x018 36+36 1.71	8x031 100+100 0.77	8x032 110+110 0.69	8x033 120+120 0.62	8x034 130+130 0.56	8x035 140+140 0.51	8x036 150+150 0.46
0x017	30+30 0.25	2x019 40+40 0.62	4x019 40+40 1.55	8x034 130+130 0.56	8x035 140+140 0.51	8x036 150+150 0.46	8x037 160+160 0.42	8x038 170+170 0.38	8x039 180+180 0.35
(encased in ABS plastic)		2x020 45+45 0.55	4x020 45+45 1.38	8x037 160+160 0.42	8x038 170+170 0.38	8x039 180+180 0.35	8x040 190+190 0.32	8x041 200+200 0.29	8x042 220+220 0.26
30 VA		2x021 50+50 0.50	4x021 50+50 1.25	8x040 190+190 0.32	8x041 200+200 0.29	8x042 220+220 0.26	8x043 240+240 0.23	8x044 260+260 0.21	8x045 280+280 0.19
70 x 30mm 0.45Kg Regulation 18%		2x022 55+55 0.45	4x022 55+55 1.13	8x043 240+240 0.23	8x044 260+260 0.21	8x045 280+280 0.19	8x046 300+300 0.17	8x047 320+320 0.15	8x048 340+340 0.14
1x010	6+6 2.50	2x023 60+60 0.40	4x023 60+60 1.00	8x046 300+300 0.17	8x047 320+320 0.15	8x048 340+340 0.14	8x049 360+360 0.12	8x050 380+380 0.11	8x051 400+400 0.10
1x011	9+9 1.66	2x024 65+65 0.37	4x024 65+65 0.93	8x049 360+360 0.12	8x050 380+380 0.11	8x051 400+400 0.10	8x052 420+420 0.09	8x053 440+440 0.08	8x054 460+460 0.07
1x012	12+12 1.25	2x025 70+70 0.34	4x025 70+70 0.85	8x052 420+420 0.09	8x053 440+440 0.08	8x054 460+460 0.07	8x055 480+480 0.06	8x056 500+500 0.05	8x057 520+520 0.05
1x013	15+15 1.00	2x026 75+75 0.31	4x026 75+75 0.77	8x055 480+480 0.06	8x056 500+500 0.05	8x057 520+520 0.05	8x058 540+540 0.04	8x059 560+560 0.04	8x060 580+580 0.03
1x014	18+18 0.83	2x027 80+80 0.28	4x027 80+80 0.71	8x058 540+540 0.04	8x059 560+560 0.04	8x060 580+580 0.03	8x061 600+600 0.03	8x062 620+620 0.02	8x063 640+640 0.02
1x015	22+22 0.68	2x028 85+85 0.26	4x028 85+85 0.65	8x061 600+600 0.03	8x062 620+620 0.02	8x063 640+640 0.02	8x064 660+660 0.02	8x065 680+680 0.01	8x066 700+700 0.01
1x016	25+25 0.60	2x029 90+90 0.24	4x029 90+90 0.60	8x064 660+660 0.02	8x065 680+680 0.01	8x066 700+700 0.01	8x067 720+720 0.01	8x068 740+740 0.01	8x069 760+760 0.01
1x017	30+30 0.50	2x030 95+95 0.22	4x030 95+95 0.56	8x067 720+720 0.01	8x068 740+740 0.01	8x069 760+760 0.01	8x070 780+780 0.01	8x071 800+800 0.01	8x072 820+820 0.01
80 VA		2x031 100+100 0.20	4x031 100+100 0.50	8x070 780+780 0.01	8x071 800+800 0.01	8x072 820+820 0.01	8x073 840+840 0.01	8x074 860+860 0.01	8x075 880+880 0.01
90 x 30mm 1Kg Regulation 12%		2x032 105+105 0.19	4x032 105+105 0.48	8x073 840+840 0.01	8x074 860+860 0.01	8x075 880+880 0.01	8x076 900+900 0.01	8x077 920+920 0.01	8x078 940+940 0.01
3x010	6+6 6.64	2x033 110+110 0.18	4x033 110+110 0.45	8x076 900+900 0.01	8x077 920+920 0.01	8x078 940+940 0.01	8x079 960+960 0.01	8x080 980+980 0.01	8x081 1000+1000 0.01
3x011	9+9 4.44	2x034 115+115 0.17	4x034 115+115 0.43	8x079 960+960 0.01	8x080 980+980 0.01	8x081 1000+1000 0.01	8x082 1020+1020 0.01	8x083 1040+1040 0.01	8x084 1060+1060 0.01
3x012	12+12 3.33	2x035 120+120 0.16	4x035 120+120 0.40	8x082 1020+1020 0.01	8x083 1040+1040 0.01	8x084 1060+1060 0.01	8x085 1080+1080 0.01	8x086 1100+1100 0.01	8x087 1120+1120 0.01
3x013	15+15 2.60	2x036 125+125 0.15	4x036 125+125 0.38	8x085 1080+1080 0.01	8x086 1100+1100 0.01	8x087 1120+1120 0.01	8x088 1140+1140 0.01	8x089 1160+1160 0.01	8x090 1180+1180 0.01
3x014	18+18 2.00	2x037 130+130 0.14	4x037 130+130 0.35	8x088 1140+1140 0.01	8x089 1160+1160 0.01	8x090 1180+1180 0.01	8x091 1200+1200 0.01	8x092 1220+1220 0.01	8x093 1240+1240 0.01
3x015	15+15 2.22	2x038 135+135 0.13	4x038 135+135 0.33	8x091 1200+1200 0.01	8x092 1220+1220 0.01	8x093 1240+1240 0.01	8x094 1260+1260 0.01	8x095 1280+1280 0.01	8x096 1300+1300 0.01
3x016	25+25 1.60	2x039 140+140 0.12	4x039 140+140 0.31	8x094 1260+1260 0.01	8x095 1280+1280 0.01	8x096 1300+1300 0.01	8x097 1320+1320 0.01	8x098 1340+1340 0.01	8x099 1360+1360 0.01
3x017	30+30 1.33	2x040 145+145 0.11	4x040 145+145 0.29	8x097 1320+1320 0.01	8x098 1340+1340 0.01	8x099 1360+1360 0.01	8x100 1380+1380 0.01	8x101 1400+1400 0.01	8x102 1420+1420 0.01
3x018	30+30 1.33	2x041 150+150 0.10	4x041 150+150 0.27	8x100 1380+1380 0.01	8x101 1400+1400 0.01	8x102 1420+1420 0.01	8x103 1440+1440 0.01	8x104 1460+1460 0.01	8x105 1480+1480 0.01
3x019	30+30 1.33	2x042 155+155 0.09	4x042 155+155 0.26	8x103 1440+1440 0.01	8x104 1460+1460 0.01	8x105 1480+1480 0.01	8x106 1500+1500 0.01	8x107 1520+1520 0.01	8x108 1540+1540 0.01
3x020	110 0.72	2x043 160+160 0.08	4x043 160+160 0.24	8x106 1500+1500 0.01	8x107 1520+1520 0.01	8x108 1540+1540 0.01	8x109 1560+1560 0.01	8x110 1580+1580 0.01	8x111 1600+1600 0.01
3x021	110 0.72	2x044 165+165 0.08	4x044 165+165 0.23	8x109 1560+1560 0.01	8x110 1580+1580 0.01	8x111 1600+1600 0.01	8x112 1620+1620 0.01	8x113 1640+1640 0.01	8x114 1660+1660 0.01
3x022	110 0.72	2x045 170+170 0.07	4x045 170+170 0.22	8x112 1620+1620 0.01	8x113 1640+1640 0.01	8x114 1660+1660 0.01	8x115 1680+1680 0.01	8x116 1700+1700 0.01	8x117 1720+1720 0.01
3x023	110 0.72	2x046 175+175 0.07	4x046 175+175 0.21	8x115 1680+1680 0.01	8x116 1700+1700 0.01	8x117 1720+1720 0.01	8x118 1740+1740 0.01	8x119 1760+1760 0.01	8x120 1780+1780 0.01
3x024	110 0.72	2x047 180+180 0.06	4x047 180+180 0.20	8x118 1740+1740 0.01	8x119 1760+1760 0.01	8x120 1780+1780 0.01	8x121 1800+1800 0.01	8x122 1820+1820 0.01	8x123 1840+1840 0.01
3x025	110 0.72	2x048 185+185 0.06	4x048 185+185 0.19	8x121 1800+1800 0.01	8x122 1820+1820 0.01	8x123 1840+1840 0.01	8x124 1860+1860 0.01	8x125 1880+1880 0.01	8x126 1900+1900 0.01
3x026	110 0.72	2x049 190+190 0.05	4x049 190+190 0.18	8x124 1860+1860 0.01	8x125 1880+1880 0.01	8x126 1900+1900 0.01	8x127 1920+1920 0.01	8x128 1940+1940 0.01	8x129 1960+1960 0.01
3x027	110 0.72	2x050 195+195 0.05	4x050 195+195 0.17	8x127 1920+1920 0.01	8x128 1940+1940 0.01	8x129 1960+1960 0.01	8x130 1980+1980 0.01	8x131 2000+2000 0.01	8x132 2020+2020 0.01
3x028	110 0.72	2x051 200+200 0.04	4x051 200+200 0.16	8x130 1980+1980 0.01	8x131 2000+2000 0.01	8x132 2020+2020 0.01	8x133 2040+2040 0.01	8x134 2060+2060 0.01	8x135 2080+2080 0.01
3x029	110 0.72	2x052 205+205 0.04	4x052 205+205 0.15	8x133 2040+2040 0.01	8x134 2060+2060 0.01	8x135 2080+2080 0.01	8x136 2100+2100 0.01	8x137 2120+2120 0.01	8x138 2140+2140 0.01
3x030	110 0.72	2x053 210+210 0.04	4x053 210+210 0.14	8x136 2100+2100 0.01	8x137 2120+2120 0.01	8x138 2140+2140 0.01	8x139 2160+2160 0.01	8x140 2180+2180 0.01	8x141 2200+2200 0.01
3x031	110 0.72	2x054 215+215 0.03	4x054 215+215 0.13	8x139 2160+2160 0.01	8x140 2180+2180 0.01	8x141 2200+2200 0.01	8x142 2220+2220 0.01	8x143 2240+2240 0.01	8x144 2260+2260 0.01
3x032	110 0.72	2x055 220+220 0.03	4x055 220+220 0.12	8x142 2220+2220 0.01	8x14				

MACHINE CODE PROGRAMMING

Is relative addressing an example of keeping it in the family? This, and other questions, will be answered in the third part of our series on Machine Code Programming, written by Bob Bennett.

Last month I gave a couple of CPU addressing mode examples, but before I give any more I would like to explain a couple of things. First, whenever possible, I will give other CPU direct equivalents to the Z80 instructions, but I can't possibly mention every CPU. What I hope to do is make it possible for you to recognise your own particular CPU instructions. To help you do this, don't pay too much attention to the name of the addressing mode, but rather what happens because of the instruction; different manufacturers have, at times, used slightly different terminology to describe similar actions. The second point is that every example I will give the hex code first followed by the mnemonic thus, 00h — NOP.

Although machine code doesn't use line numbers, the BASIC statement GO TO 100 has a very near equivalent in machine code, but the comparison cannot be taken too literally. These equivalents are the **jump** or **branch** instructions, part of which form the relative addressing mode. In this mode the instructions are two bytes long, the first byte is the function, and the second is the offset. The Z80 instruction set the straightforward jump instruction code is 18h — JR,e, or jump relative by the amount of the offset byte e. Why relative? Well, the value of the offset byte indicates a destination for the jump, relative to the current program position.

Because the offset is only one byte, the maximum jump is 255d (d = decimal) or Ffh locations, but in which direction? The numbers 0 to 255d are positive, so a forward direction is indicated; this leaves the problem of going backwards. No sweat, the answer lies in the use of the 2's complement. Never heard of it? Don't worry, all will become clear.

Take the maximum range of a byte, 0 to 255d, and split it; the first section, 0 to 127d (7Fh) are the forward or positive range. The second step is where it might get confusing so watch it carefully: the numbers that are left from 128 to 255d or 80 to FFh, but, because we need a backwards, or negative, direction, the decimal numbers now range from -128 to -1.

Remember that I said you would need a knowledge of the binary system? This is where it comes in handy. The binary equivalents of the decimal numbers 0 to 127 and 128 to 255 are 0000 0000 to 0111 1111 and 1000 0000 to 1111 1111 respectively. A closer examination shows that, throughout the first set of numbers, but 7, the leftmost bit, is 0; and throughout the second set, bit 7 is 1.

This makes it possible for bit 7 to be used as a sign bit: reset, or 0, for positive; and set, or 1, for negative. To get the value of the offset byte is easy. Counting the byte after the offset byte in the program as zero,

count backwards or forwards until you reach the destination for the jump, as shown in Fig. 6. Another method would be to take the destination address, and the zero address, take the lower from the higher, and add the sign accordingly.

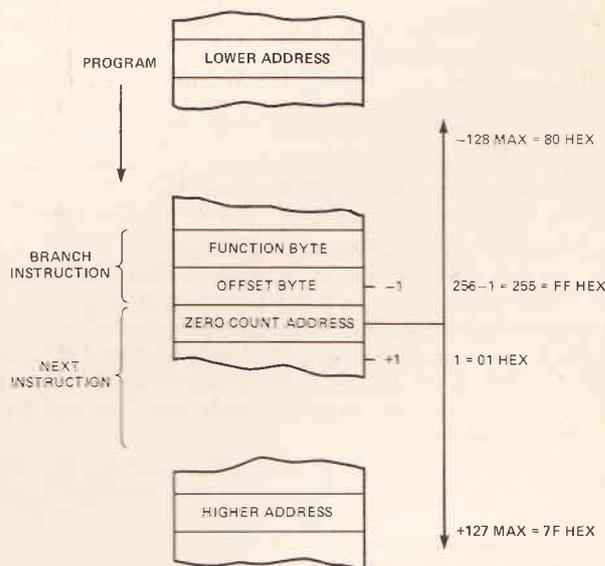


Fig. 6 Counting the value of the offset byte.

Assume that you have counted 100 places backwards; Fig. 7 shows what happens next. Alternatively, if you subtract the backwards count from 256d, the answer is a decimal number equal to the 2s complement, which you then convert to hex.

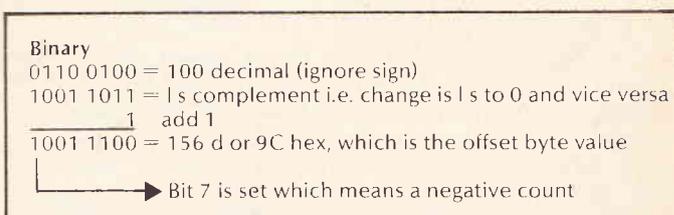


Fig. 7 2's complementing a backwards (negative) count.

Some CPUs do not have a straightforward relative jump/branch in the instruction set, but some do support the conditional relative jumps/branches. This is similar to the BASIC IF X = 0 THEN GO TO 100. The Z80 instruction 28h — JR Z,e means jump relative if the zero flag is set, by the amount of the offset e. The 6502 code is F0h — BEQ which means branch when zero flag set. Usually most of the flags can be used in

the set or reset condition for relative jump or branch instructions.

Absolutely So

Although the relative jumps and branches are sometimes of great help in a program, their range is rather limited as I have shown. To get further afield requires slightly different techniques, and different instructions of course. This set of instructions require an absolute destination, or address, to be specified in the instruction. For those of you who like analogies, relative addressing is like saying 'go to the third house past the church' and the absolute equivalent is 'go to 31 Church Street'. This type of jump or branch is only a part of the absolute addressing mode instructions, but for now I'll deal with jumps.

Because, in theory, the whole of our 64K memory

FIRST STEP: divide decimal address by 16

$$16 \overline{) 30,000} \begin{array}{r} 1,875 \\ \underline{30,000} \\ 0 \end{array} \text{ remainder } 0 = 0 \times \text{units}$$

SECOND STEP: divide this by 16

$$16 \overline{) 1,875} \begin{array}{r} 117 \\ \underline{1,872} \\ 3 \end{array} \text{ remainder } 3 = 3 \times 16$$

THIRD STEP: divide again by 16

$$16 \overline{) 117} \begin{array}{r} 7 \\ \underline{112} \\ 5 \end{array} \text{ remainder } 5 = 5 \times 16$$

As the result is less than 16, we stop therefore 30,000 decimal = 7530 hexadecimal

Fig. 8 One way of converting decimal to hex.

is reachable, the addresses will have to be in two bytes, so the total bytes for absolute addressing is at least three. There are special cases that require just one byte, and some that need four, but I'll cover them later. Let's assume for now that we need to jump unconditionally to address 30,000d; Fig. 8 shows how to prepare the decimal number into the two byte hex number we need.

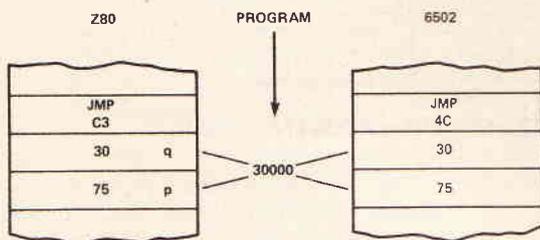


Fig. 9 Absolute jump instructions.

The Z80 instruction C3 — JP pq, where pq are the address bytes, and the 6502 instruction, 4C — JMP are both examples of jump in the absolute mode. Fig. 9 shows how both examples would be used in a program, when the destination was address 30,000d. Note that the low byte of the address goes straight after the code for jump; please accept that this is so for now, and I'll explain more later on.

In some of the instruction sets the flags status, or condition, can be used just as in the relative jumps.

Leaving the jump/branch instructions let's have a look at some more absolute instructions. The Z80 instruction 3A — LD A,(pq) means load the A register with the contents of the address pq. Note the use of brackets in the mnemonic; without them the instruction would mean: load the A register with the two byte number pq; two into one won't go! To get the

number in the A register into the address pq, the instruction in the Z80 set is 32 — LD (pq),A.

This mode of addressing need not be restricted to a single register; a Z80 example is 2A — LD HL,(pa), where the byte in pq is loaded into L and the byte in pa+1 is put into H. If you forget which byte goes where, just remember H for high (byte), and L for low; using the DE pair, the high byte will go into register D.

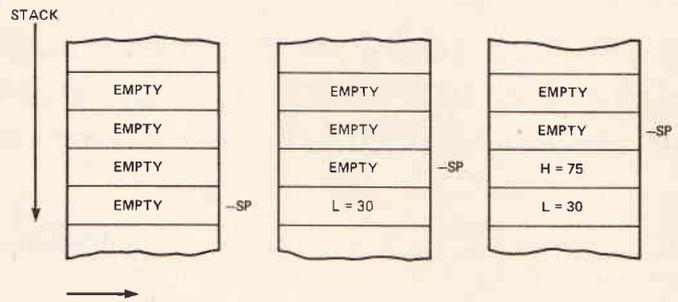


Fig. 10 Pushing the number 7530hex in the HL pair.

Those of you with Sinclair micros may have noticed, in the manual appendix dealing with the character set, the words 'after ED' or 'after CB' etc. This is where a four byte absolute instruction may be found, and is explained as follows. The instruction 4B in the Z80 set means LdC,E, but after ED means LD BC,(pq). Fig. 10 shows how this is used in a program. The use of ED and CB, etc., is very similar in principle to the use of shift keys, where one key with shift has a different function to the unshifted version.

A Direct Extension

This section should explain, in part at least, some of the differences in terminology that I mentioned earlier. In one book I read a few weeks ago, the author gave an example of absolute addressing, using 3A — LD A,(pq) for the Z80 set. He went on to say that this mode is sometimes called the direct or extended mode. As the 6800 set uses both of these modes I'll give a couple of examples.

In the direct mode, the instruction 96h is concerned with loading the accumulator with the byte held in an address, but there is only one byte used for the address. This is because the high byte of the address is supplied by the computer automatically, and the byte is 00. So, when the computer meets the instruction 96,FF, it interprets it as meaning Ld A,(pq), where pq is 00FF. An example of the extended form from the 6800 set is 87 — LD (pq),A where the two bytes pq must be put in by the programmer. As a last example, I'll use the 8085 set; in that set 3A — Ld A,(pq) is considered as being in the direct mode.

Now for a little bit more explanation of terminology. That 6800 direct mode example I gave above is sometimes called **zero page addressing**, or sometimes, **abbreviated absolute form**. No matter what it is called, it still works in the manner that I have described. Those of you with a 6502 can use zero page addressing, which simply means the first page (of RAM) runs from addresses 0000 to 00FF. All you have to do as a programmer is specify the low byte of the address from 00 to FF, and the computer adds the 00 automatically, as already explained. Now you can see that it does help to know how your computer has its memory mapped out. A computer that has ROM starting at address 0000 cannot use zero

FEATURE : Machine Code

page addressing in the form **Ld (pq),A**, because you cannot write to ROM.

Pop Goes The Weasel

In the instructions that I've already covered, the two bytes, pq, have been used as an address. Later on I will be giving addressing mode using pq as numbers, but for now more explanations. These explanations concern not only what has gone before, but what is yet to come. Firstly, let us recall the stack pointer register, SP, as we'll be looking at this in rather more detail.

As you will recall, the stack is a portion of RAM which the computer reserves for its own use, and, like the variables area, the size can fluctuate. The stack is used to store two byte addresses or numbers, either at the command of the programmer, or as part of a computer controlled sequence. Curiously, the stack is sort of upside down, with the latest piece of information going on top of the one before, which makes for a last in, first out, situation.

To help you understand the stack, and the manipulation of pq, I am going to use two single-byte instructions. These are the **PUSH** and **POP**, or **PUSH** and **PULL** instructions. Because pq takes up two bytes push and pop concern register pairs. The Z80 set allows the push and pop of every register pair (see part one of this series) and also allows the A register to be paired with the flags register, F, for this purpose. Don't be misled, though: the use of the AF pair allows only A to be loaded (with any number up to FFh), but you can't load the F register.

Using the HL pair to make things clearer, the Z80

instruction **EF — PUSH HL** will store the contents of HL on the stack. See Fig. 10 while following the explanation. Supposing HL contained the number or address 30,000d or 7530h before the instruction **E5 — PUSH HL** was encountered by the program. On reaching E5 the stack pointer will be pointing to the next empty address available on the stack. First the low byte in L is copied into that address. The stack pointer, sp, is then decremented (by one) and the high byte in H is copied into the new address pointed to by SP. The register is decremented again so that it is now pointing to the next available address.

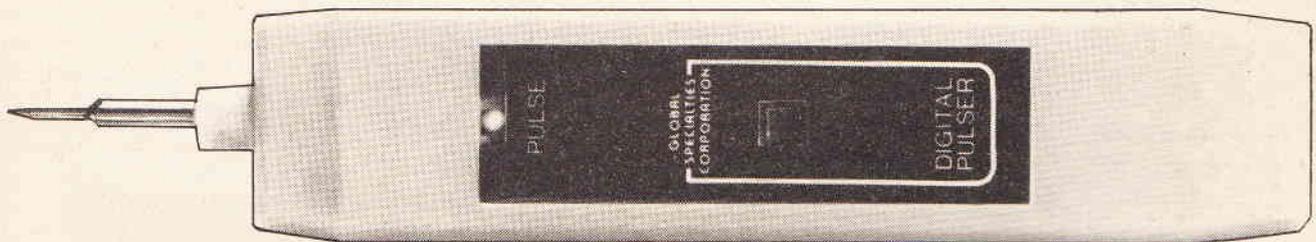
The reverse happens on the pop instruction which, in the Z80 set is **E1 — POP HL**. This instruction will increment SP (by 1), the byte in the new address is copied into H; SP is incremented again, and the next byte goes into L. Now SP is pointing to the next available address on the stack.

The 6502 set allows the pushing and popping of only two single registers onto the stack. These are the accumulator and the status register; for example, **48 — PHA** copies the contents of the accumulator onto the stack. Notice that I keep saying copies onto the stack: this is to emphasise the fact that pushing does not destroy the contents of registers.

The final couple of points will be of interest to Z80 users mainly. If you have pushed a sequence of register pairs onto the stack, before popping them off again remember the last in, first out rule. Having said that, what happens if you push HL then pop DE? With that question, we'll leave you pondering until ETI pops through your letter box next month...

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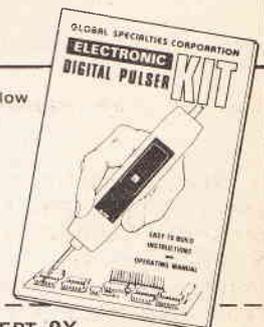


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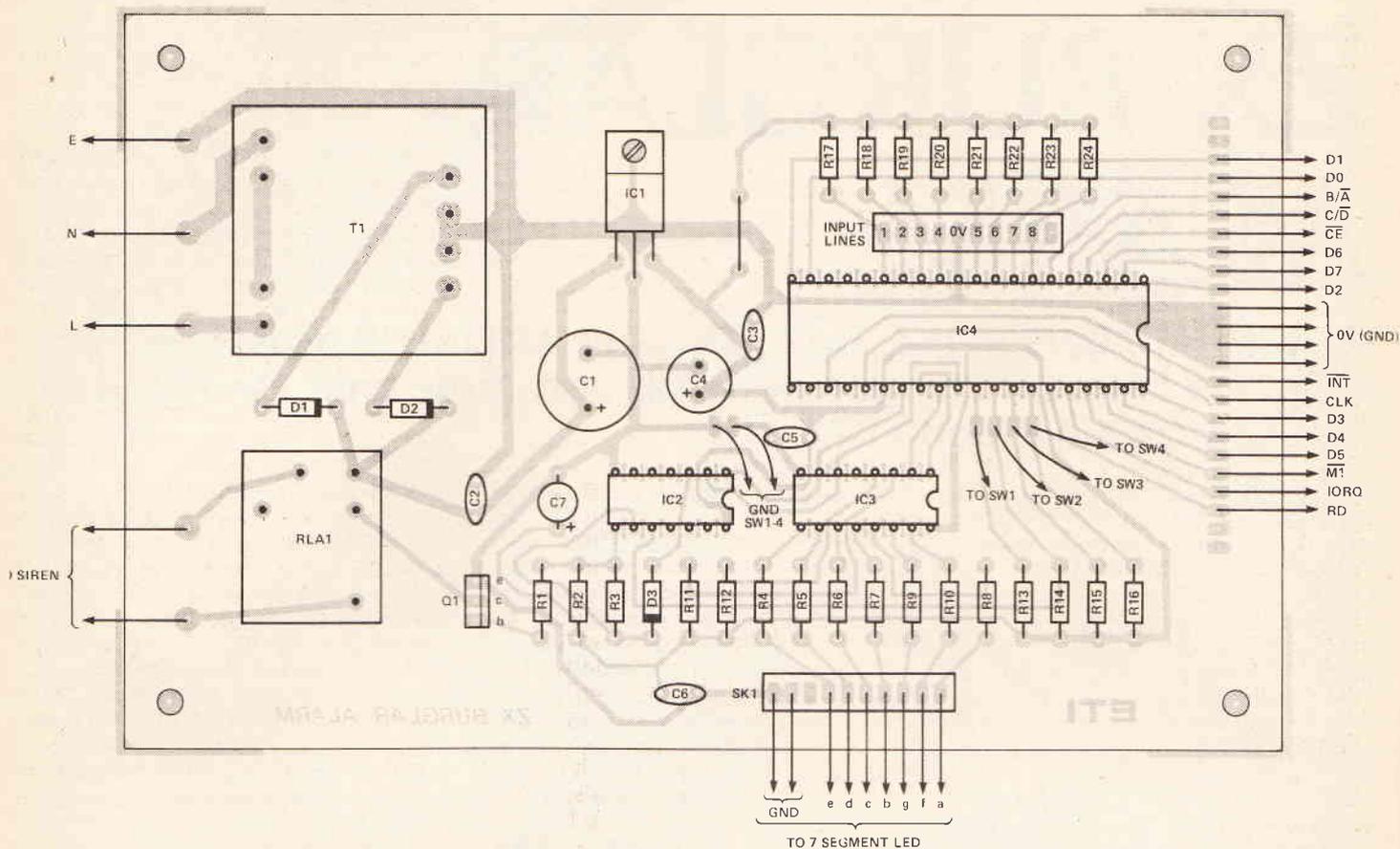


Fig. 2 Overlay diagram of the PCB.

switches respectively). The contents of this register are then continuously compared with the inputs to port A and if any discrepancy is discovered a '9' is sent out to the display. A timing loop, formed by loading a high number into the registers H, L, and then successively subtracting one until the result is zero, ensures that the nine is displayed for at least a second or so, after which the number of the affected input is displayed. An AND gate monitors the

A and D data lines into the display driver and thus goes high when the 9 is output, the delay ensuring that it remains high long enough to latch the relay and thus sound the alarm.

Construction

Most of the components, including the relay and the transformer, are mounted on the PCB, the only off board components being the switches, the LED display, the edge connector to suit

either ZX81 or Spectrum, and the siren or other output transducer. Make sure that all four ICs are inserted the right way around, and similarly check the electrolytic capacitors C1, C4, and C7, and the diodes. Provision has been made for the use of connectors for the LED display and the input lines but if you prefer you can, of course, solder directly to the board. It is intended that the relay should switch a siren or similar device which draws its power from an

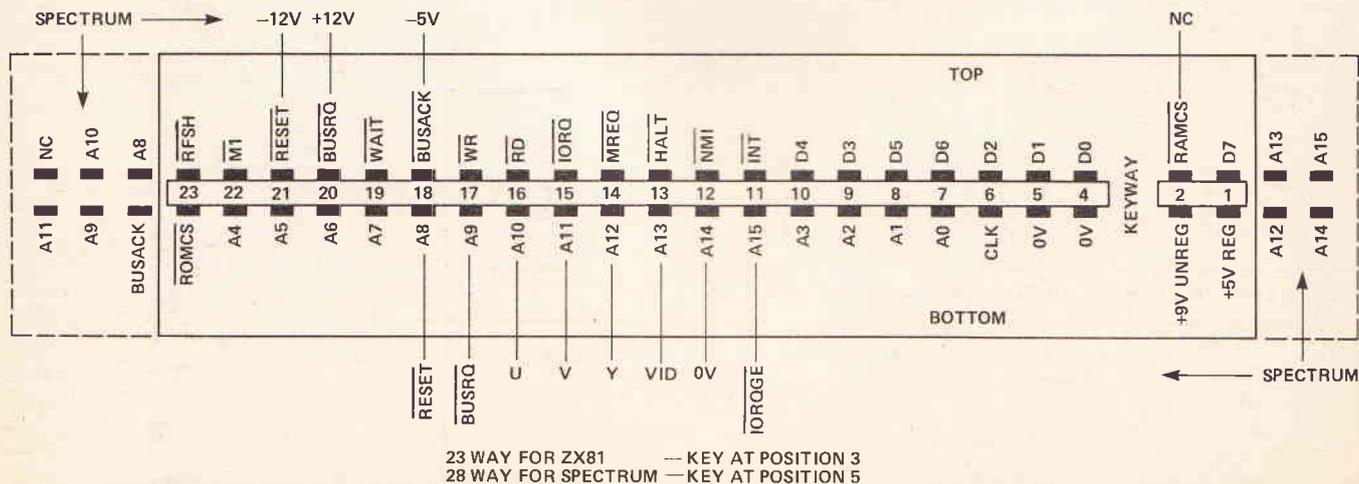


Fig. 3 Pin connections of the ZX81 and Spectrum expansion ports.

PROJECT : ZX Burglar Alarm

PARTS LIST

Resistors (all 1/4W, 5%)	
R1	4k7
R2, 4, 5, 6, 7, 8, 9, 10	470R
R3	330R
R11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	10k
Capacitors	
C1	1000u 16V electrolytic
C2, 3	100n
C4	22u 16V electrolytic
C5, 6	10n ceramic
C7	100u 10V tantalum
Semiconductors	
IC1	7805
IC2	7408
IC3	7447
IC4	Z80A PIO
Q1	BD131
D1, 2	1N4001
D3	1N4148
DISP1	Common anode 7-segment display
Miscellaneous	
T1	9-0-9V 6VA PCB mounting transformer
SW1, 2, 3, 4	momentary action, push-to-make
RLA1	12V DC 400R miniature relay
PCB: edge connector to suit ZX81 or Spectrum; 10-way 0.1" pitch PCB plug and socket — 2 off each; case, etc to suit	

BUYLINES

All of the semiconductors, including the Z80A PIO, are readily available from a number of our regular advertisers, as are suitable transformers, ZX81 and Spectrum edge connectors, 7-segment LEDs and the switches. A suitable relay is sold by both Maplin (code YX97F) and Ambit (type OUD), both of whom also supply PCB connectors. The PCB is available through our PCB services, for which see page 74.

A7	A6	A5	A4	A3	A2	A1	A0	PORT
0	0	0	1	1	1	1	1	A data
0	1	0	1	1	1	1	1	A control
0	0	1	1	1	1	1	1	B data
0	1	1	1	1	1	1	1	B control

Table 1 Examples of eight bit PIO address words.

BIT	7	6	5	4	3	2	1	0
output mode	0	0	1	1	1	1	1	1
input mode	0	1						
bidirectional	1	0						
control	1	1						

Table 2 Format of the operation control word.

external source, eg the mains, but if your particular application does not specifically demand an ear-drum piercing, complaint eliciting siren, you might prefer to use an audible warning device of some sort instead. Providing this does not draw more than 100 mA or so and will run from 17V or less, you can connect it directly in the collector circuit of Q1 and dispense with the relay entirely. The edge connector you use to connect the unit to the micro will depend on whether you plan to use a ZX81 or a Spectrum, and should be wired in accordance with Fig. 3.

The choice of case is left entirely to the constructor, but since there is mains on the board it is advisable to have some sort of enclosure. Mounting the switches should present no problems but the LED display is not so easy. If you're after a particularly neat appearance you would perhaps do best to go for an easily cut plastic case, and to cut out an aperture for the LED and then mount it flush in Araldite. The input lines, mains input, and connections to the microcomputer could either be taken through grommets or, if you're really fussy, through appropriate connectors, although it is probably most convenient to use a connector only for the input lines.

Programming

The Z80 PIO ahas six control lines, three of which (MI, IORQ, and RD) can be connected directly to their counterparts on the Spectrum or ZX81 edge connector. The remaining three, B/A SEL (select port A or B), C/D SEL (select either control or data carried on bus), and CE (chip enable) must be connected to the address bus. The Spectrum manual tells us that A0, A1, A2, A3, and A4 are all normally high (they are used to

control printer, loudspeaker, etc), so we can leave these high and connect B/A SEL, C/D SEL, and CE to the remaining three lines, A5, A6, and A7 respectively. A5 low selects port A, A5 high selects port B; A6 low selects data (input and output) and A6 high selects control (programming information). A7, the chip enable, is always held low. The resulting eight bit words are shown in Table 1 and their decimal values are 31, 93, 63, and 127 respectively.

We must next initialise the PIO by sending two control words to each port. The first defines which mode and, as we are using mode three, a second must be sent to define which of the eight lines are inputs and which outputs. The format of the operation control word is shown in Table 2, and it will be seen that the relevant control word for ports A and B is 11111111, that is, decimal 255.

The second control word also consists of eight bits, each one corresponding to the I/O line with the same number, ie, bit 0 corresponds to PA (or PB) 0, bit 1 corresponds

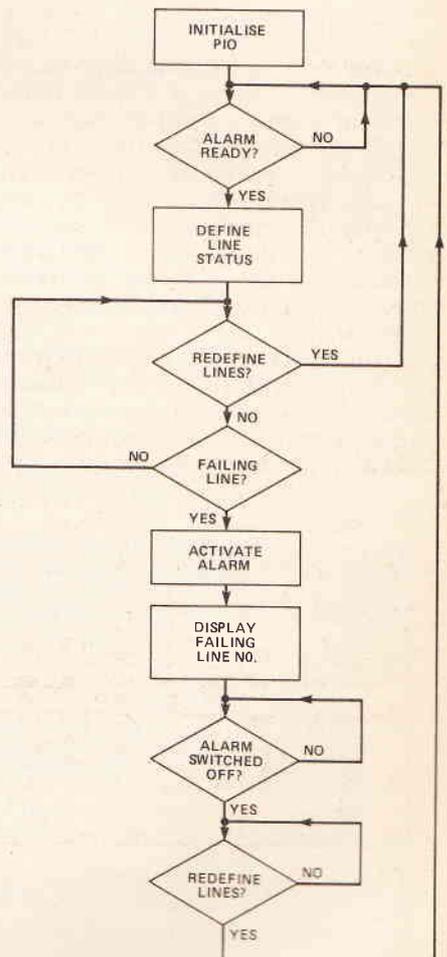


Fig. 4 Flow chart of the burglar alarm program.

```

10 Clear 32500
15 For n = 0 to 107 : read b
20 Poke 32500 + n , b
25 Next n
30 DATA 62, 255, 211, 93, 211, 93,
211, 127, 62, 240, 211, 127, 219, 63,
203, 111, 40, -6, 6, 8, 62, 0, 30, 0,
60, 211, 63, 219, 63, 203, 119, 40, 5,
203, 127, 32, -10, 28, 219, 63,
203, 111, 32, -6, 203, 11, 16, -24, 62, 0,
211, 63, 219, 63, 203, 103, 40, -46, 219,
31, 171, 6, 8, 203, 23, 56, 4, 16, -6,
24, -19, 197, 62, 9, 211, 63, 6, 10,
17, 1, 0, 33, 222, 57, 237, 82, 32, -4,
16, -9, 193, 120, 211, 63, 219, 63,
203, 111, 32, -6, 219, 63, 203, 103, 32,
-6, 24, -96
40 PRINT USR 32500

```

Table 3 The Spectrum program.

to PA1, etc. Setting the bit high defines the associated I/O line as an input, while setting it low defines it as an output. Since port A consists of the eight input lines from the various sensing switches, its control word will be 11111111, again, decimal 255. Port B has lines 0, 1, 2, 3 outputting data to the LED display and lines 4, 5, 6, and 7 accepting input data from the push button switches, so its control word will be 11110000, that is, decimal 240.

The first six instructions of the program therefore consist of loading the relevant control word into the accumulator and outputting it to either address 93 or address 127 (see Table 5 and the flow chart, Fig. 4).

The program can be entered directly into the Spectrum, but if you are using a ZX81 you will need to reserve space for the 108 bytes of machine code by moving RAMTOP. To do this type in:

```

POKE 16388,147
POKE 16389,67
NEW

```

and follow each statement with the Newline command. To check that RAMTOP has been moved, type in:

```

PRINT 256*PEEK 16389+PEEK
16388

```

and you should get 17299.

The ZX81 is also unable to deal directly with the negative numbers used in the jump statements. The

computer recognises a negative number by checking to see if the most significant bit of the jump operand is high. If so, then this bit represents -128, all other bits retaining their normal values. For example, suppose we wish to enter -6. This becomes -128 +122, or in binary 11111010 (the first digit representing -128 and the remaining seven representing +122). This is the decimal number 250. This can also be calculated from the two's complement rule: the number (6) in binary

00000110

change 0 to 1, 1 to 0

11111001

add 1

11111010

which is again decimal 250. Thus, any number having the form -X can be entered by using the formula $128 + (128 - X)$ which is, of course, simply $256 - X$.

Having reserved the 108 bytes after RAMTOP in the ZX81, type in:

```

10 FOR N=0 to 107
20 INPUT X
30 POKE 17299+N,X
40 NEXT N
50 PRINT USR 17299

```

then RUN. The computer will then wait for you to type in the 108 numbers given in Table 4. Note that these are the same numbers as those in the Spectrum program except that all the negative numbers have been replaced with their

```

62, 255, 211, 93, 211, 93, 211, 127, 62, 240,
211, 127, 219, 63, 203, 111, 40, 250, 6, 8,
62, 0, 30, 0, 60, 211, 63, 219, 63, 203, 119,
40, 5, 203, 127, 32, 246, 28, 219, 63, 203,
111, 32, 250, 203, 11, 16, 232, 62, 0, 211,
63, 219, 63, 203, 103, 40, 210, 219, 31, 171,
6, 8, 203, 23, 56, 4, 16, 250, 24, 237, 197,
62, 9, 211, 63, 6, 10, 17, 1, 0, 33, 222, 57,
237, 82, 32, 252, 16, 247, 193, 120, 211, 63,
219, 63, 203, 111, 32, 250, 219, 63, 203, 103,
32, 250, 24, 160

```

Table 4 (Above) The ZX81 data.

Table 5 (Right) Assembler listing of the burglar alarm program.

LD A	255	62,	255	
out A	93	211,	93	
out A	93	211,	93	
out A	127	211,	127	
LD A	240	62,	240	
out A	127	211,	127	
IN	63	219,	63	
BIT 5		203,	111	
JRZ	-6	40,	-6	
LD B	8	6,	8	
LD A	0	62,	0	
LD E	0	30,	0	
INC A		60,		
out A		211,	63	
IN	63	219,	63	
BIT 6		203,	119	
JRZ	5	40,	5	
BIT 7		203,	127	
JRNZ	-10	32,	-10	
INC E		28,		
IN	63	219,	63	
BIT 5A		203,	111	
JRNZ	-6	32,	-6	
RRE		203,	111	
DJNZ	-24	16,	-24	
LD A	0	62,	0	
out	63	211,	63	
IN	63	219,	63	
BIT 4		203,	103	
JRZ	-46	40,	-46	
IN	31	219,	31	
XOR E		171,		
LD B	8	6,	8	
RLA		203,	23	
JC 4		56,	4	
DJNZ		16,	-6	
JR	-19	24,	-19	
PUSH B		197,		
LD A	9	62,	9	
out	63	211,	63	
LD B	10	6,	10	
LD DE	1	17,	1,	0
LD HL	14814	33,	222,	57
SBC HL, DE		237,	82	
JRNZ	-4	32,	-4	
DJNZ	-9	16,	-9	
POP B		193		
LD A, B		120		
out 63		211,	63	
IN 63		219,	63	
BIT 5		203,	111	
JR NZ	-6	32,	-6	
IN 63		219,	63	
BIT 4		203,	103	
JRNZ	-6	32,	-6	
JR	-96	24,	-96	

PROJECT : ZX Burglar Alarm

HOW IT WORKS

The various intruder detecting switches are connected between earth and the eight lines of port A on the PIO. Each of the eight lines is connected to the +5V line through a pull-up resistor, so that when the associated switch is open a logic high level will appear on the input, and when the switch is closed the line will be pulled down to logical low. The latter four lines on port B are similarly connected so that pushing any of switches 1 to 4 takes the associated line low. The first four lines on port B are used for the display output and carry a four bit binary code. This is fed directly to the decoder/driver 7447 and thence to the seven segment display.

When the program is started up it puts out a '1' and then waits for the line to be defined. Taking either line 6 or line 7 on port B low enters a 0 to 1 as desired into register E. Subsequently taking line 5 low initiates a rotate right instruction which moves the entered data one place to the right so that the register is ready to receive the next bit. The microprocessor then outputs a '2' and the process is repeated until register E is full.

The microprocessor then goes into a continuous loop, using the XOR function to simultaneously compare each input line with the corresponding bit

in register E. If both bits are at the same level, either both high or both low, the XOR function will produce a 0 output, but if the two bits are at different logic levels the XOR will give a 1. The RLA instruction is used to shift each bit into the carry flag and test for a 1 and if no carry is detected the microprocessor carries on testing the lines.

When a 1 is detected, a nine is briefly sent out via port B to the display. At the same time, a large number is loaded into registers H and L and 1 is successively subtracted until the result is zero. A total of 148,140 machine cycles are needed for this, and the nine is therefore displayed for a full second or so before the microprocessor removes it and displays instead the number of the failed line. The AND gate IC2b has its inputs connected to the A and D lines from port B, and will therefore go high only when a nine is put out. Its output is connected to IC2a, another AND gate, which is wired as a latch. IC2a drives the transistor Q1 which turns on the relay. The other input of IC2a is connected to line 5 of port B, and if SW2 is pressed this line will go low, unlatching the gate and thus turning off the relay.

two's complement.

From here on the procedure is the same whichever microcomputer you are using. When the programming has been completed, a 1 should appear on the LED display. This refers to the first line on port A, and you must now tell the computer whether this line is to be high or low, according to what type of sensing switch you plan to use on it. To do this you first press either switch SW3 (LOW) if the line is to be normally closed or SW4 (HIGH) if the line is to be normally open, and then press the ENTER switch SW2. The LED should now display a 2, and you repeat the procedure with this and each of the subsequent lines.

When all eight lines have been entered and the register is full, the microprocessor goes into a continuous loop, checking each line against its corresponding bit in the register. Should you wish to redefine the normal state of the lines, pressing SW1 empties the register and thus stops the program. If the alarm is triggered, it can be reset by pressing first SW2 and then SW1.

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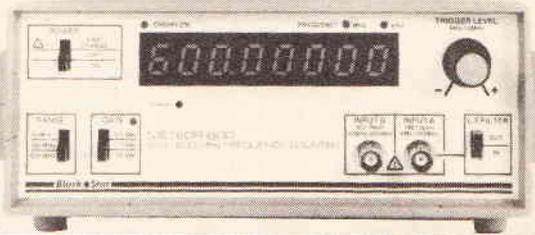
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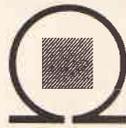
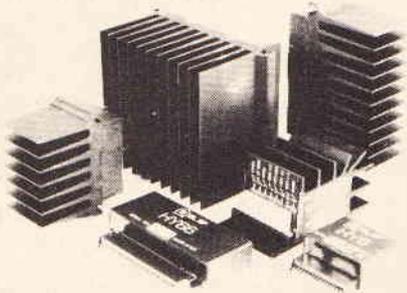


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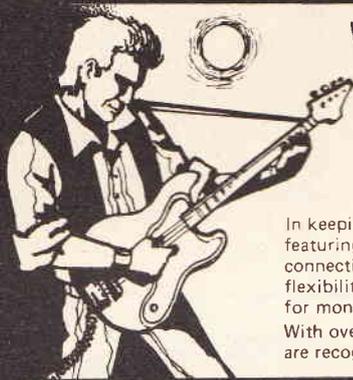
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AUDIO DESIGN

Whether or not a preamplifier needs tone controls is controversial; however, what is beyond dispute is that a competent audio engineer needs to know how to design them. John Linsley Hood shows the way.

With the exception of the response curve corrections needed for the proper replay of gramophone records recorded to the RIAA characteristic, so far I have looked mainly at linear amplifier systems, such as the low distortion gain block and the moving coil head amplifier circuits shown in the previous part of this series. What if one wants deliberately to enhance part of the audio spectrum? How does one do it? Well, doing it is easy, but there are some snags, and I think it would be useful to look at these first.

Once upon a time, all proper hi-fi amplifiers had tone controls. Now, most of the very up-market ones don't. Why is that? Being somewhat cynical about the hi-fi scene (and close acquaintance with this field tends rather to encourage this sort of response to the claims, beliefs and motives of those within it), the most immediate answer might be that what you don't put in won't go wrong, nor does the manufacturer have to pay for the bits that haven't been used. A second, less cynical though perhaps more naive thought could be that if you have very up-market gear, the frequency response of all your bits will be so good that any tinkering with the frequency response will be quite unnecessary. The truth, which could include parts of both of the above, would also recognise that one gets nothing for free, and that a beneficial change in the frequency response might also cause problems elsewhere.

Consider first the question of harmonic distortion. As we have seen, this is due to the presence of unwanted harmonics of the signal frequency, so that a 300 Hz signal will be accompanied by unwanted signals at 600, 900, 1200, 1500 Hz, and so on, representing the 2nd, 3rd, 4th and 5th harmonics of the incoming signal. If we give the signal a little treble boost, say +6dB at 1500 Hz, we would have doubled the amount of 5th harmonic present — and this is an unpleasant one, which is quite discordant — as well as increasing the amount of the others present, to greater or lesser degrees. True, the converse also applies. A treble cut will reduce the amount of harmonic distortion, so that, for example, the purity of the sinewave output from an audio signal generator can be improved just by putting a few RC filter elements after its output. Those of us who are old enough will remember the old trick of putting a 0.02 μ F across the primary of the speaker transformer winding to lessen the amount of third harmonic in the old pentode valve output stages.

At the other end of the frequency spectrum, while a bit of bass boost may help to give a punchy quality to a drum or string bass, or impress your friends by making your doors rattle on an organ pedal note, the penalty could be an enhanced response to mains hum, or rumble from the gramophone turntable or record. More subtly, the penalty might be just that the low frequency signals, because they occur at frequencies where our ears are not very sensitive, tend to be rather large in

amplitude, so that a bit of bass boost might make them so big that they actually overload our amplifiers or LS systems. This last is very likely, since LS driver cones tend to move in and out quite a bit at LF anyway, because of the very limited air loading at these frequencies.

So, how about filtering the signal to remove the turntable rumble, or other very low frequency signals for which the LS will tend to flap its cone, before applying the bass boost? Yes, this would be better, but even filtration has snags, tonally. These come about because rates of change of signal amplitude with frequency greater than -6dB/octave (where the signal amplitude halves as the frequency is halved — or doubled) occur very rarely indeed in nature, so our ears respond to higher rates of change as an 'unnatural' sound, or a 'colouration'. As an example of this, if we take a wideband 'white' noise signal, and we modify the amplifier frequency response by a filter having a -6dB/octave characteristic, as shown in Fig 1a, the 'hiss' will sound a bit different, and a bit quieter, but it will still sound uncoloured.

If we increase the filter slopes, as in 1b, and 1c, to -12dB and -18dB/octave, the sound of the hiss will change, and begin to take on a somewhat 'tuned' quality, characteristic of the turn-over frequency. The steeper the filter slope, the worse this will be. This is a criticism which has been levelled at the digital recording systems, where the very steep cut, 'brick wall', anti-aliasing, filters needed for this technique, will introduce very heavy colouration. Fortunately, the steep cut filter frequency is sufficiently high that the 'whistly' quality of the sound will be noticeable only to those with young ears.

The moral of this is, I think, that we should use bass or treble boost with discretion, and never more than we need. Similarly, where possible, we should avoid filters having very steep slopes unless these slopes are variable so we can adjust them to give an aurally acceptable result.

Such steep-cut AF filters, used with 'bi-amped' and 'tri-amped' hi-fi LS systems, where the crossover

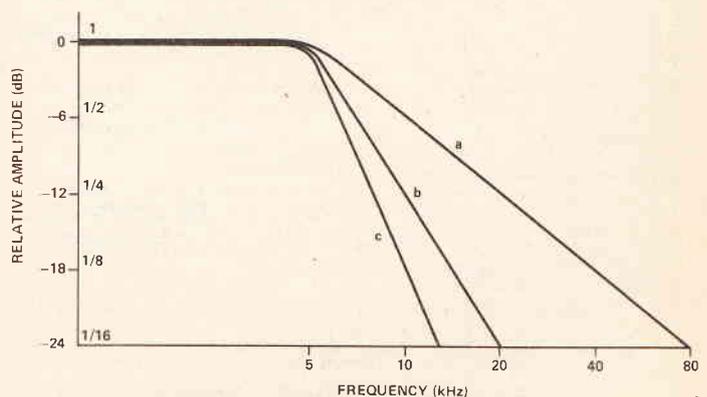


Fig. 1 Effect of different filter slopes.

between woofer, mid-range and tweeter units is accomplished electronically at the input to separate LF, mid-range and HF power amplifier units, can give results which are a lot less good than expected, simply because of the phase changes of the signal and the colouration of the final result. The actual crossover networks in the better commercial LS multi-driver systems tend to owe as much to listening tests and small adjustments to the component values as they do to the initial calculations. These are the snags: now for the circuitry.

Tone Controls

These come in five basic types, each representing an attempt to avoid problems or give better results. These I shall call conventional, shelf, slope, graphic equaliser and parametric types.

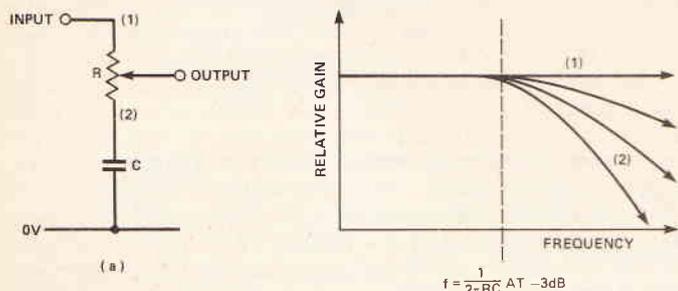


Fig. 2 A very simple treble cut tone control

Conventional Tone Controls

As we have seen, the impedance of a capacitor is related to frequency by the equation $Z_c = 1/2\pi fC$. This means that the simple RC circuit of Fig. 2a would, if driven by a sufficiently low source impedance and loaded by a sufficiently high output impedance, have an output at (1) as shown in 2b (flat with frequency) and an output at (2) which falls at 6dB/octave with increasing frequency, as shown also in 2b. If R is a potentiometer, the gradient of the slope can be varied according to whereabouts one taps off the output. This will give a simple treble cut 'tone control'. If one modifies the circuit a little, as shown in Fig. 3a, to include a resistor R2, to limit the attenuation when the impedance of C has fallen to a very low value, and if one makes C a lot bigger in value, the output at (2) will rise below a certain frequency, dependent on the component values, to give the frequency response shown in Fig. 3b. This could be made

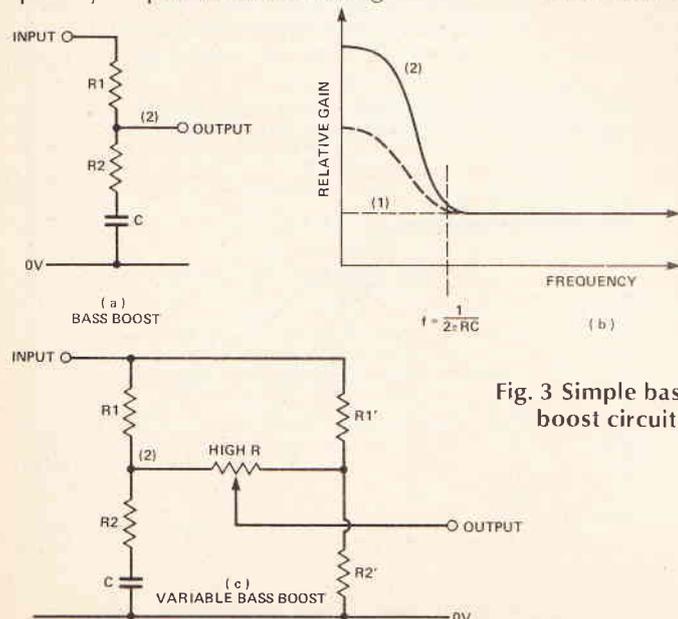


Fig. 3 Simple bass boost circuits.

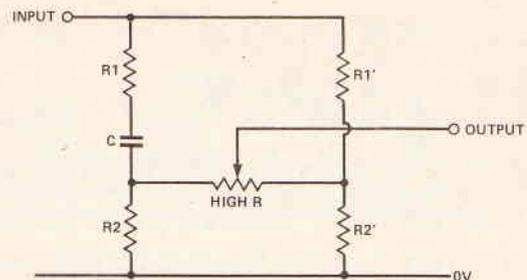


Fig. 4 A simple treble boost (or bass cut) circuit.

into a variable bass boost control by the circuit layout of Fig. 3c.

A similar sort of exercise can be done to make passive (ie, built entirely from Rs and Cs, with no amplifying elements) bass cut and treble lift arrangements, as shown in Fig. 4. Inevitably we will need to work out some means of interconnecting these so that they don't interact, and several such circuits, as for example in Fig. 5, have been worked out, and were popular in the USA. The question is really whether it is worth the bother, when the excellent arrangement first proposed by Mr. P. Baxandall, shown in Fig. 6, will do all that is needed just as well and more neatly.

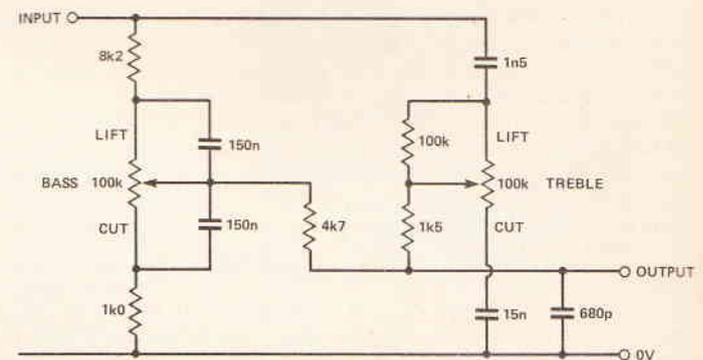


Fig. 5 Typical (commercial) passive tone control circuit.

The big advantage supposedly centred by passive tone control circuits is that because they only contain Rs and Cs they won't distort the signal. However, they will attenuate the signal — since they only work by selective attenuation, a 20dB 'lift' at one frequency is simply a 20dB attenuation everywhere else in the spectrum. Therefore it is necessary to amplify it by 10 (=20dB) either before or after the passive tone control stage, and this amplifier may distort.

Also, there is the question of where this amplifying stage should be put. If this TC stage has an attenuation of 20dB, and 1 V RMS output is needed from it, a 10 V RMS input signal (at least) is needed for its input — and this is a pretty big signal for a preamp. So — what if the amplifier is put so that it follows the TC stage? Then it only has an output of 1 V RMS, so it will have a reasonably low distortion, but there will be a lot of Rs and Cs connected to its input, which is now at only the 100 mV level, and which makes the task of getting a good S/N ratio, and low background hum level, just that much more difficult.

The Baxandall circuit avoids this difficulty, since, in the flat frequency response position of the controls, it will normally have unity gain, so 1 V out requires 1 V in, which presents few problems in S/N ratio or hum pick-up. The way this circuit works is best explained by the simplified circuit of Fig 7, which is a straightforward negative feedback inverting amplifier, whose gain is R_b/R_a . If $R_b = 10R_a$, then the gain is 10. If $R_b = R_a$, the gain is 1. If

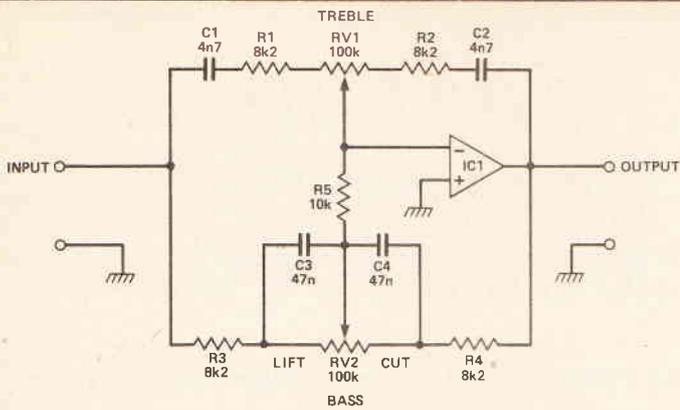


Fig. 6 Typical negative feedback tone control circuit of the Baxandall type.

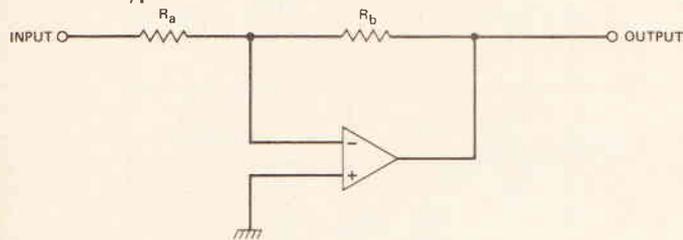


Fig. 7 Simplified feedback circuit.

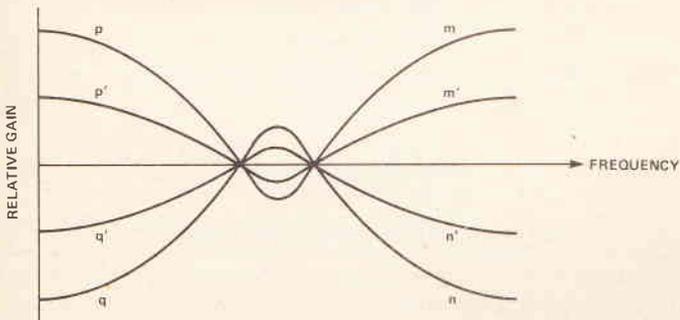


Fig. 8 Behaviour of negative feedback tone control (overlap effects exaggerated).

$R_a = 10R_b$, then the gain is 0.1, and so on. Referring back now to Fig 6, C_1+R_1 and C_2+R_2 are RC combinations whose impedance decreases with frequency. If the setting of RV1 is such that ' R_a ' is largely due to C_1+R_1 , then the amplifier will follow the gain curve (m) in Fig 8. If the slider on RV1 is moved to the other end of its travel, so that it is now R_2+C_2 which is equivalent to ' R_b ', then the gain curve will follow the form (n) in Fig. 8.

R_3+C_3 in Fig 6, is a network whose impedance increases as the frequency decreases, so that, by a similar argument, the curves (p) and (q) of Fig 8 can be

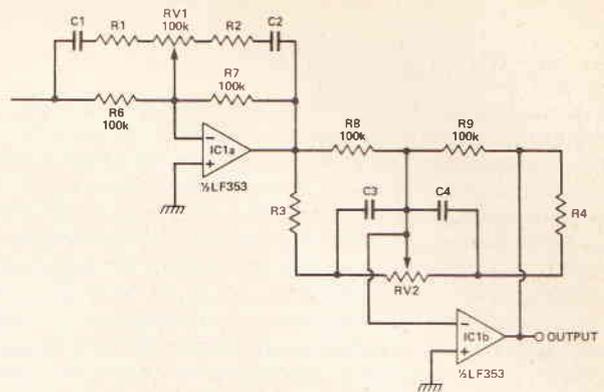


Fig. 9 Sequential two-stage tone control which avoids interaction between controls (component numbering of Fig. 8 retained except for new components R6 and R7 needed for DC feedback, and absence of R5).

selected by appropriately positioning the slider on RV2. The intermediate curves p', q', m' and n' can be selected at intermediate positions of the sliders on RV1 and RV2, with a flat frequency response being obtained, if the components are closely matched, when the sliders of the pots are exactly in the middle of their travel. The resistor R5 serves to help isolate the operation of the 'bass' and 'treble' sections of the tone control. This isolation is, however, always a bit less than perfect, so the perfectionist might prefer to separate out the two halves in two successive stages, as shown in Fig 9, using two halves of a dual op-amp. The limit resistors R1, R $\bar{1}$, R3 and R4 in both cases serve to prevent the circuit from trying to give an infinite gain or a zero gain at the extreme potentiometer slider positions.

Shelf-Type Tone Controls

This is a compromise between the Baxandall and Graphic Equaliser type tone control systems, in which a series of RC networks are arranged so that they can give separate 6dB shelves in the frequency response, which can be added (or subtracted) at will, at octave elements in the audio pass band. This gives a very similar type of response correction to that of the graphic equaliser (though more limited in amplitude) but without the snag of the very uneven frequency response which the graphic equaliser will give at max. or min. settings. Provided that only relatively small amounts of correction are needed, this arrangement allows for separate octave band portions of the frequency response to be raised or lowered independently. Typical possible frequency response curves are shown in Fig. 10, and a circuit for this type of tone control is shown in Fig 11.

Fig. 10 (LH corner) Typical frequency response curves for two-stage shelf control (desired frequency response can follow any one of these patterns).

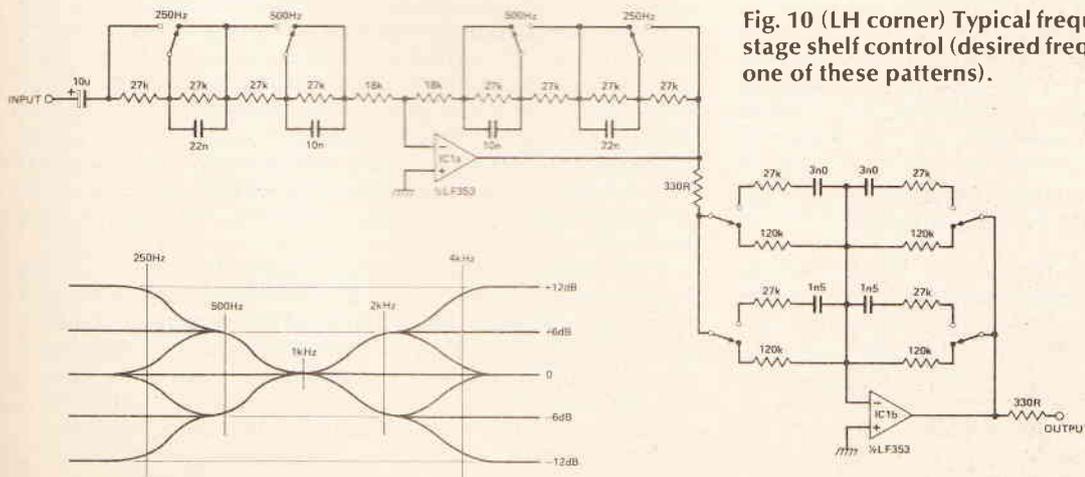


Fig. 11 Circuit layout for two-step shelf-type tone control.

Slope Controls

The realisation that, with good quality audio equipment and good programme sources, the major requirement of the normal user would be to alter the general slope of the amplifier frequency response, to correct a somewhat over dull or over shrill quality in the input signal (the preferences of the original sound engineer may differ from ones own or from any other engineer), led the Acoustical Manufacturing Co., in their Quad 44 preamp., to provide for the skewing of the frequency response, to give an overall upward or downward slope to the response curve, of the type shown in Fig. 12. A typical circuit for this, due to Quad, is shown in Fig. 13.

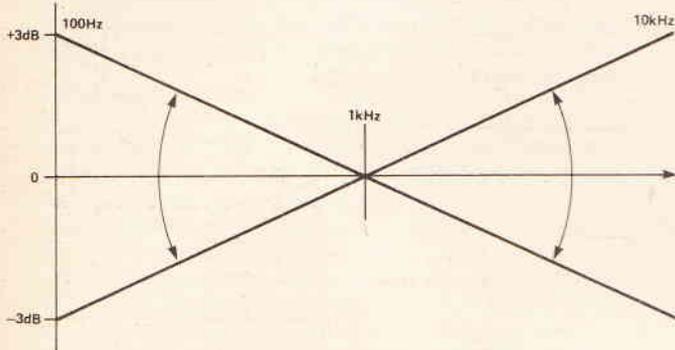


Fig. 12 Slope type tone control.

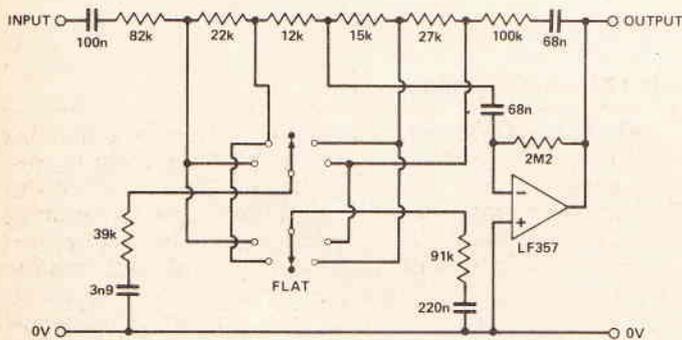


Fig. 13 'Quad' tilt control.

Graphic Equaliser Systems

The basic idea behind this development was a good one, and the scheme enjoyed a considerable popularity when it was first introduced in the early 1970s. In essence, the idea is that in a normal listening room environment, and with normal LS and gramophone PU units, the frequency response of the system — at the ears of the listener — will contain a number of humps and troughs, most of which will probably be quite localised. Therefore, if one could divide up the acoustic spectrum into eight, single-octave chunks — which would cover the range from 60Hz to 15.3KHz — and if some provision were made for adjusting the gain of the preamp, upwards or downwards, in each of these sections, it should be possible to make a pretty fair job of organising a flat frequency response, as actually presented to the listener.

Well, by and large, the system works. The first snags are the obvious ones — that nature does not often oblige by putting its humps or troughs in the frequency response just at the centre frequency points (90, 180, 360, 720, 1440, 2880Hz, and so on) which such an eight octave equaliser would offer, they are just as likely to occur at the interface frequencies where we could do nothing about them. The other snags are those which arise from the nature of the corrected frequency respon-

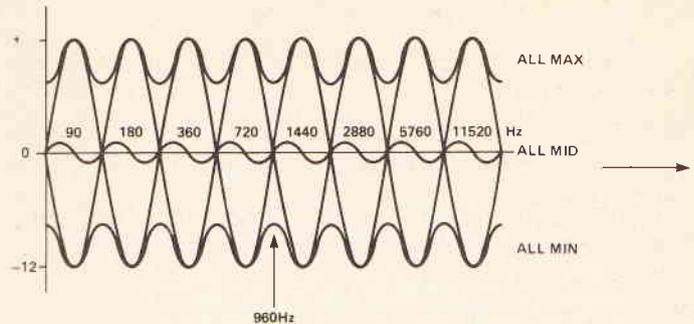


Fig. 14 Response of a graphic equaliser tone control system

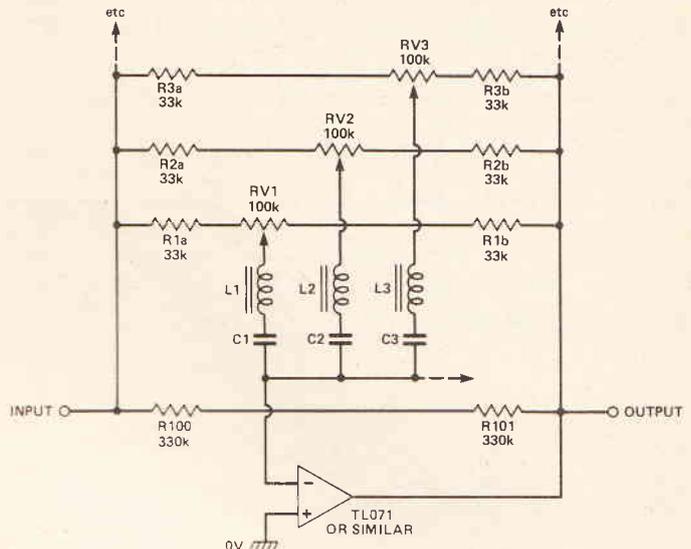


Fig. 15 Circuit arrangement of a graphic equaliser.

se, of which the possibilities are shown in Fig. 14. These are: with all the controls set to their mid-point positions the frequency response tends to have a corrugated iron appearance; furthermore, if all controls are set to either max. or min. positions, this irregularity is much exaggerated; and all rapid changes in gain vs. frequency are accompanied by very large phase shifts. The sound of a transient (percussive) event is very dependent on the relative phase (= time of arrival) of the sound components which go to make up this event; if one churns up the phase components, one gets some strange effects.

So, with a little regret, the consensus of opinion is that such tone correction systems, unless used very judiciously, tend to diminish the realism of the reproduced sound. However, for those who would use such systems judiciously, the circuitry needed is shown in Fig. 15.

This operates by utilising the characteristic of a series resonant LC circuit, such as L1/C1, to provide a very low impedance path at its resonant frequency. Left to itself, the op amp, IC1, with R100 and R101, would be a unity gain inverting amplifier. If RV1 is large in relation to the other circuit resistors (R1a, R1b), when the slider of RV1 is at its left hand end, the gain of the circuit (at the frequency at which L1/C1 has a nominal zero (impedance) will be given by: $E_{in}/E_{out} = R_{101}/(R_{1a} // R_{100})$ ("// means "in parallel with"), which will be higher than unity gain.

If, on the other hand, the slider of RV1 is at its right hand end the gain of the circuit (at resonance of L1/C1) will be $E_{in}/E_{out} = (R_{101} // R_{1b})/R_{100}$, which could be a good bit less than unity. So, this gives a means of adjusting the gain up or down at specific frequencies determined by the resonant frequency of the LC series network. Other series resonant limbs, L2/C2, L3/C3 etc., can be connected, in parallel, as shown, with little interaction.

The actual resonant frequency of this network can be calculated from the equation $F = 1/(2\pi)LC$, which can be rearranged conveniently as $L = 1/(2\pi F)^2C$, where F is in Hz, C is in farads, and L is in henries. This gives values for L and C for 90 Hz as 3.1 H and $1\mu F$, for 720 Hz as 500 mH and 100nF and so on. The actual value shown on the circuit diagram will give about 12dB lift and cut; more than this would be unwise.

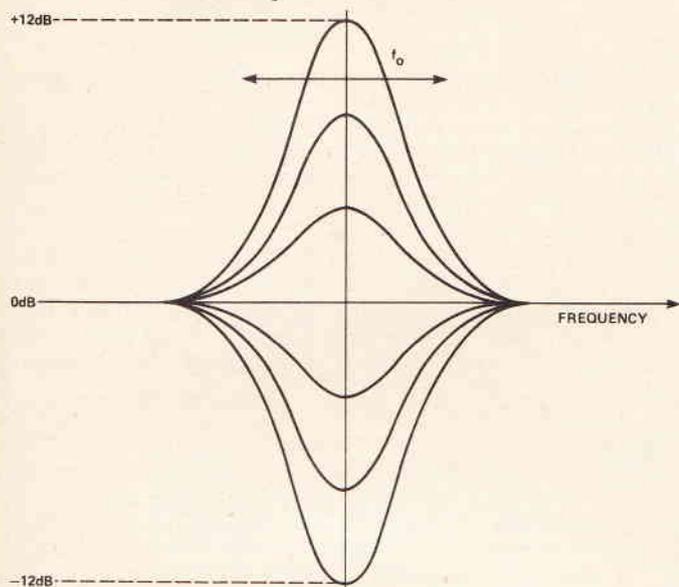


Fig. 16 Parametric tone control response.

Parametric Equaliser Type

This has similarities to that of the graphic equaliser system, but is more modest in its intended scope. In this arrangement, a correction is applied to a single point in the frequency passband (although, in principle, more could be used), and provision is made not only for modifying the amplitude from peak to notch, but also for moving it up and down the frequency spectrum, so that it could be positioned precisely at the point at which a tonal correction is required. Such a system could be made by taking a single section of the circuit of Fig. 15, and altering its operating frequency by adjustments to L1 or C1 by switching, though in the rather complex published circuits the resonant frequency is usually generated by the use of gyrators, which are electronically simulated inductors. The frequency response is shown in Fig. 16.

Impedance Matching

In general, all of these tone control circuits, and most of the other preamp circuits will operate at their best if they are driven from a very low impedance, and loaded with a very high impedance. Most op amps, or gain blocks connected in this manner, will have a low output impedance, due to the operation of the negative feedback system. If they are connected as non-inverting amplifiers they will generally have a high input impedance. If they are connected as inverting stages, the input impedance will be that of the circuit elements connected between the input and the - input connection to the op amp. This will not normally be very high, but will usually be a lot higher than that of an op amp direct output connection. If a tone control circuit is driven from too high an input impedance, the maximum lift available will be lowered, and the interaction between the treble and bass controls will be increased. If an 'active' filter is driven from too high a source impedance it may be unstable.

Filters

All of the RC tone control circuits described above will give a maximum lift or attenuation characteristic of 6dB/octave — associated with a maximum phase shift of 90° beginning at the octave below a treble lift or cut, or at one octave above a bass turn-over point. (this phase shift is not particularly important in tone control systems, but should be remembered as an unavoidable accompaniment of any frequency response adjustment mechanism.) If a greater rate of attenuation is needed, for example for HF whistle removal or for rumble filtering, a wide variety of steep cut filter circuits are available.

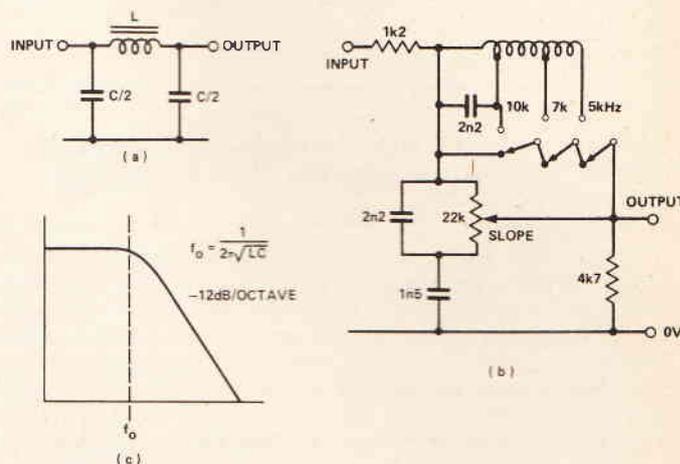


Fig. 17 LC low-pass filter system.

Of these, the simplest is the LC system shown in Fig. 17a. This is quite often used in treble filter circuits, and the arrangement shown in Fig. 17b is the three-frequency variable slope filter of the Quad 33 preamp. Although one could also use this arrangement as a rumble filter, this is not commonly employed mainly because the large values of inductance required would lead to a proneness to hum pick up. To get a good rate of LF attenuation, the Q of the LC network would need to be high. This is determined by the ratio L/CR (where R is the winding resistance of the choke, and its associated core losses), which means that L has to be high, so that the required low frequencies cannot be obtained simply by using a big C.

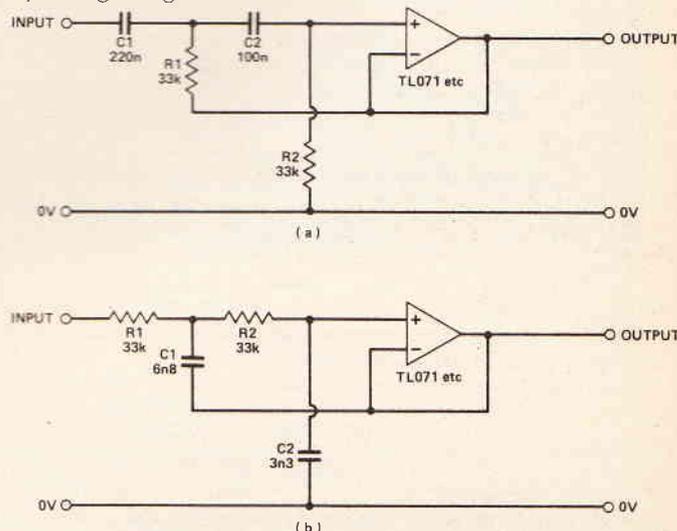


Fig. 18 Sallen and Key active filter circuits: (a) high pass (30 Hz) — 12dB per octave; (b) low pass (1 kHz) — 12dB per octave.

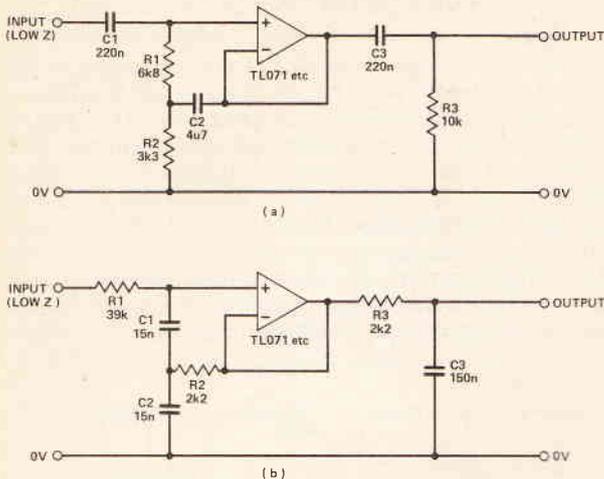


Fig. 19 Bootstrap or H filters: (a) high pass (30 Hz) -20dB per octave; (b) low pass (nominally 1 kHz, actually 1145 Hz) -20dB per octave.

More conveniently, active filter arrangements can be used, based on some power amplifying element, such as an op amp, and a group of Cs and Rs. The circuits for active filter arrangements are very numerous, but two of the most useful, which can be built around any suitable op-amp, or even an emitter follower, are the Sallen and Key and the 'Bootstrap' circuits, which I have shown in Figs. 18 and 19 in their respective high-pass and low-pass versions, together with appropriate circuit values for 1 kHz (low-pass) and 30 Hz (high-pass).

This latter value is conveniently placed for a preamp rumble filter, but all of the filter turn-over frequency

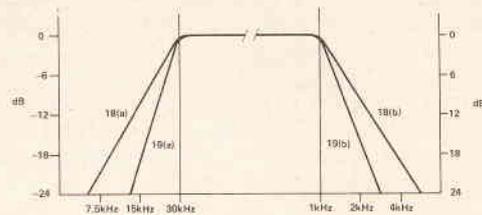


Fig. 20 Filter slopes given by treble and bass filters of Figs. 18 and 19.

points can be scaled up or down by proportional adjustments to the values of the resistors or the capacitors. One can check the correctness of ones choice from the formula $F_c = 1/2\pi\sqrt{R1R2C1C2}$.

As shown, the Sallen and Key circuits of Fig. 18 will give a -20dB/octave attenuation rate, because they have a three section structure, and one can push the Q up a bit higher. (Other things being equal they would have given -18dB/octave). The slopes obtainable are shown in Fig. 20.

The analysis of these circuits, and the method of calculating their performance is a little beyond the scope of this part of this series, but I will explore this field later, when I take a look at the use of complex numbers in calculating the impedance and phase shifts caused by reactive components in passive and active networks.

In the next part of this series I propose to take a look at audio power amplifiers, to see how these may be designed, and to try to assess the present state of development of these, and how much of the myth has a foundation.

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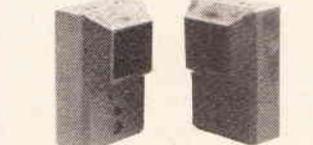
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POWER SUPPLY & RELAY UNIT PS 4012

Provides stabilised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. Price **£4.25 + V.A.T.**

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.'s of 110db's at 2 metres. Operating from 9-15V, the module contains an inhibit facility for use in 'break to activate' circuits. Price **£2.95 + V.A.T.**

5 1/2" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110db's at 2 metres) when used with the CA 1250, PS 1865 or SL 157. Price **£4.95 + V.A.T.**

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. Price **£3.43 + V.A.T.**

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SIREN & POWER SUPPLY MODULE PSL 1865



A complete siren and power supply module which is capable of providing sound levels of 110db's at 2 metres when used with a horn speaker. In addition, the unit provides stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 or US 4012 to form a complete alarm. Price **£9.95 + V.A.T.**

HARDWARE KIT HW 1250



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HARDWARE KIT HW 5063



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This hardware kit provides the necessary enclosure for a complete self-contained alarm system which comprises the US 5063, PS 1865, loud speaker type 305 and key switch 3200. Attractively styled, the unit when completed, provides an effective warning system without installation problems.

ULTRASONIC MODULE ENCLOSURE



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FINESSE LIGHT CHASER/SEQUENCER

Bored with lights that just flash on and off? Get them to chase around in pretty patterns and mesmerise your friends with the ETI Finesse Light Chaser unit. Design by Ian Benton.

The electronics controlling a disco lightshow is increasing rapidly in sophistication — so here's my attempt to do for the light chaser what ETI's "Spectracolumn" did for the sound to light unit last December. Here's the Finesse Light Sequencer.

This design uses only a similar number of components to the average light controller but provides many more functions, coming a close second in versatility to a fully microprocessor controlled light system. It provides not only the chase/invert/all-flash patterns that are available on the simplest controllers and the forward-reverse chase patterns that appear

on some of the more upmarket versions, but a selection of forty different sequences including 10 chase patterns (chase up, chase down, alternate forward reverse, chase in twos, chase in fours etc.) eight flash patterns (all flash, a short strobe-type flash, left & right alternate flashing, centre & outside alternate flashing), and 20 other sequences including chasing from both sides to the centre, etc. and two test sequences (all on and all off). In addition, the unit has both sound-chase and auto-chase facilities so the lights can be set to change in time to the music or at a constant rate determined by a front-panel mounted potentiometer.

meter.

The unit can be used to drive all manner of light boxes — certain sequences appear more impressive on different types of display up to a maximum of 375 watts per channel — any more than that and the mains fuse blows when all 8 lights turn on together — the prototype drives a long box with eight spotlights plus two square boxes with eight lamps arranged in a radial pattern.

The various sequences are stored in an EPROM with one byte (8 bits) determining the state of each of eight lamps, and 16 bytes in each sequence so that the display steps through 16 changes of

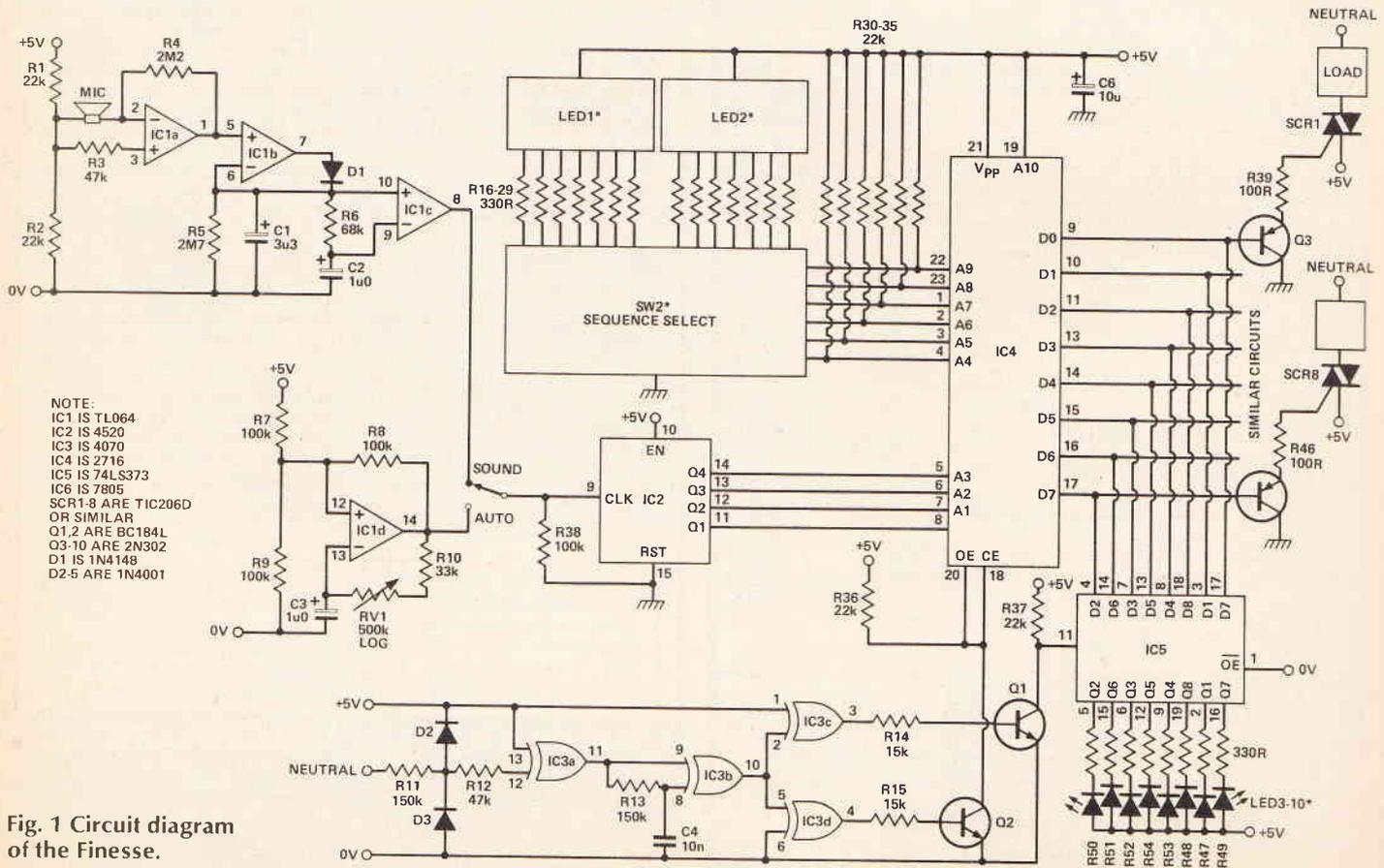


Fig. 1 Circuit diagram of the Finesse.

lights before it repeats again. The sequences are selected using a 40-way (CB rig type) switch. This produces a BCD output which is connected to address lines A4-A9 (A10 is not used), and a two digit seven segment output which drives a front panel display. As the switch has BCD outputs the addresses from A to F (hex) cannot be used, which limits the system to 40 sequences out of the possible 64.

A 2716 (16K) EPROM was chosen as the data storage device. Although only half the available memory is used it has an advantage of cost over the 8K (2758) EPROM which is now not easily obtainable, and of ease of use over the 2708 which requires in addition a -5V and +12V power supply.

Bipolar (Schottky) PROMs were considered as they are completely non volatile (an EPROM may suffer data loss if it gets too close to the disco UVs without an opaque sticky label) but these are far more expensive than the EPROM (£11 for a Schottky PROM compared to about £2.25 for an EPROM) and cannot be erased if you make a mistake during programming — you have to throw it away and start again with a new one. However, it is possible to use a Schottky PROM with a slight change to the PCB: see Modifications section.

The circuit also includes an optional LED display which shows what should be happening at the front. It was decided not to include bulb failure detection as the prototype drives three bulbs in parallel and so would only show a failure if all three bulbs blew which is fairly unlikely.

The completed circuit is split into three sections. The transformer, rectifiers, and reservoir capacitor were mounted separately as they were common to another controller which was mounted in the same box as the prototype. Note that no PCB has been given for this

section, as it is much cheaper to mount these components separately, either using a piece of Veroboard or point-to-point wiring. Do remember that **all** the PSU components are at mains potential. The sound chase board was kept separate to place the microphone behind the front panel and keep the wires between the speed control potentiometer and the oscillator circuit to a minimum to avoid pickup of unwanted signals causing spurious output pulses.

The sound chase circuit features automatic level control which eliminates the need to adjust a level control. It gives a genuine sound-chase which changes the lights on the beat instead of just varying the speed according to the volume of sound. The circuit has a fast attack and fairly slow decay so it is quite effective at picking out drum beats or cymbals. The circuit includes its own crystal microphone which is of sufficiently high quality for this application as only the general sound level needs to be detected. If you're very fussy, you could use an electret condenser microphone if you can find a 1.5V power supply for its internal JFET amplifier. The sound chase and oscillator circuits are implemented using a TL064 IC (this is the quad low-voltage low-power version of the familiar TL071).

No connection should be made to the disco sound equipment unless it is done through an isolating transformer or optoisolator as the entire sequencer circuit is at mains live potential.

As an added bonus the circuit features zero-crossing control of the triacs — this eliminates radio frequency interference which is generated if a triac turns on in the middle of a half-cycle and also reduces the current required to trigger the triacs as they are only triggered at the beginning of each half cycle.

The overall cost of the circuit

compares very favourably to a commercial unit and even to some of the simplest three channel controllers; the major part of the cost will probably be in the bulbs, bulbholders and connectors.

Construction

Be especially careful when soldering on the PCB as the tracks are very close together in places and both mains live and neutral appear on the same board. Use a good quality socket for the EPROM as you may need to remove it; the other ICs can be soldered directly if you feel confident enough, otherwise use sockets. Take care to get the tantalum capacitors the right way round (they smell terrible when they blow up) as well as the ICs and diodes.

The actual transistor types used are not critical, but the PCB is laid out for the types specified, and you will have to make sure that the right leads go down the right holes.

HOW IT WORKS

The audio signal is picked up by the crystal microphone and amplified by IC1a which has a high gain. IC1b along with D1, R5 and C1 form a peak detector which has a fast attack and slow decay. R6 and C2 follow the peak with a delay, IC1c compares the peak signal with the delayed signal and therefore produces a pulse corresponding to any sudden increase in volume.

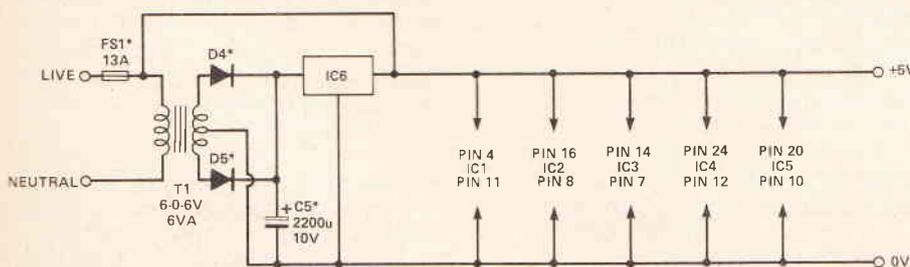
IC1d along with R7, R8, R9, R10, C3 and RV1 form a conventional Schmidt trigger oscillator with a speed variable from 0.5Hz to 10Hz. Switch SW1 switches between the Sound and Auto inputs.

IC2 is a four-bit binary counter which counts the input pulses and steps the four low-order address lines of the EPROM though the 16 bytes of the sequence.

SW2 provides the high order address lines and also drives a 7 seg display. The switches are connected between the input and ground to maintain compatibility with bipolar PROMs which require a higher pull-down current which is thus provided through the switch and not the resistors.

D2 and D3 clip the mains 50Hz sine wave and IC3a produces a square wave. This is doubled by IC3b, buffered by IC3c and inverted by IC3d to produce a positive going and a negative going pulse; these are used to enable the EPROM outputs at the beginning of each half cycle and to latch the data into the LED driver (IC5). Q3 to Q10 produce a 50mA pulse to trigger the triacs (SCR1 to SCR8) which turn the lamps on.

The power supply is fairly conventional with a transformer, rectifier diodes, reservoir capacitor and three-terminal regulator. The 5V output is connected to mains live. C6 is a decoupling capacitor for the EPROM supply.



* DENOTES COMPONENTS NOT MOUNTED ON PCBs

Fig. 2 Suggested PSU circuit.

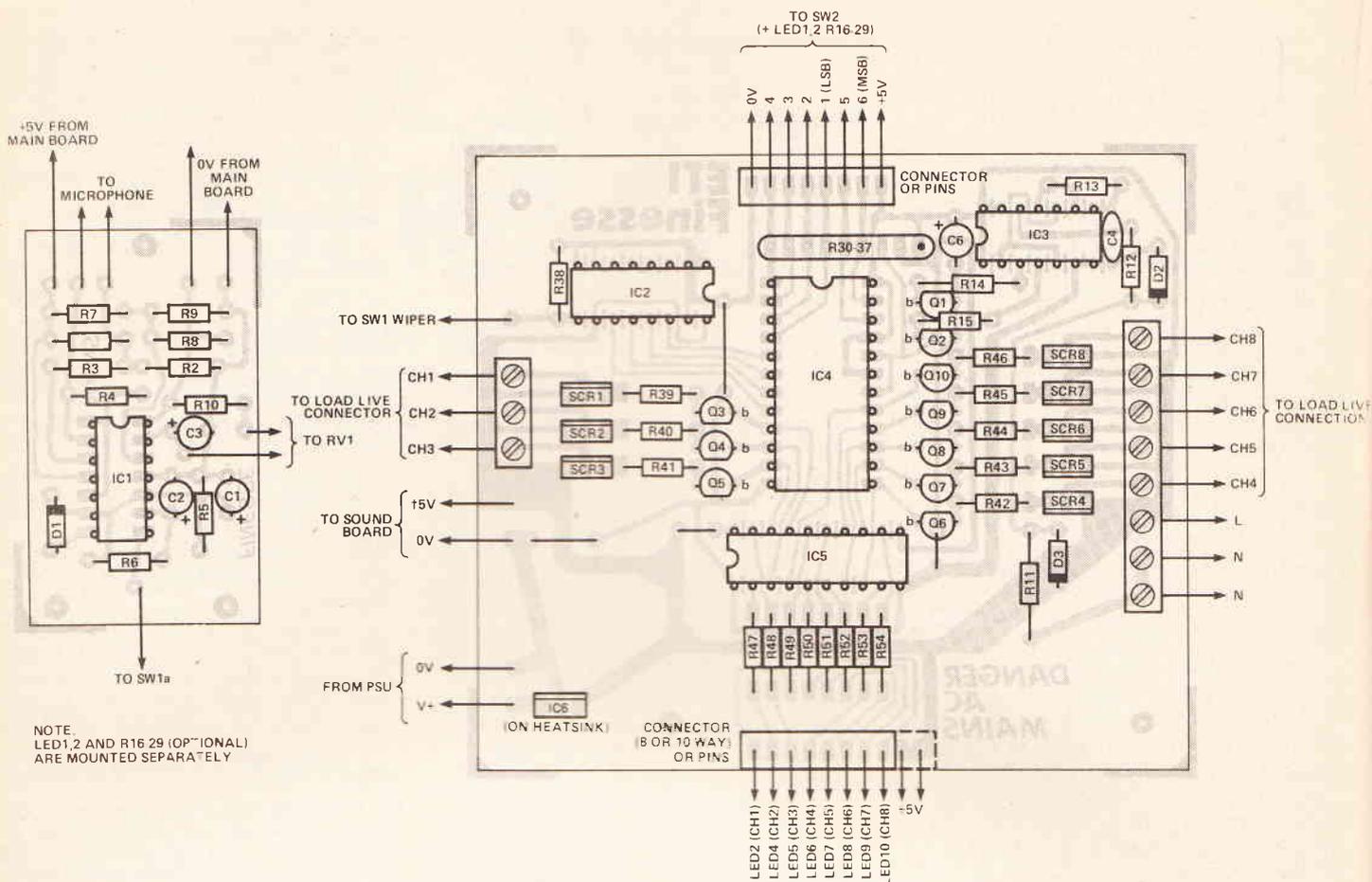


Fig. 3 Overlay diagram for the main board and the sound board (on left).

In particular, note that the pin-out of the BC184L is different from that of the BC184. Note also that IC2 and IC3 face in different directions. All the ICs apart from the TL064 and 74LS373 are MOS so require handling carefully — don't touch the pins more than you have to and make sure that your soldering iron has an earthed bit. The TL064 is JFET and LS373 is bipolar and you can touch them as much as you like!

If your crystal mic is mounted a hole in the front panel, make sure that you use a plastic-bodied type as the metal body is connected to one terminal which will therefore be at live potential.

The TL064 op-amp must not be replaced by a TL074 or TL084 even though these types are cheaper. The 74/84 only works down to 6V whereas the 64 will operate at the 5V supply used by the rest of the circuit. The EPROM can be the cheapest type available (try Rapid Electronics); this will also be the slowest, but 450ns is still plenty fast enough as the inputs are changing no faster than 20Hz and any access time better than 1 ms is good enough. If you're using your

own PCB design or Veroboard (??) then don't swap MT1 and MT2 on the triacs even though it simplifies PCB layout. These are not interchangeable and the circuit won't work with them connected the other way round (I tried it!)

A transformer is recommended for the power supply — even if you omit the LEDs you would still need a very hot resistor or hefty capacitor to provide the 70mA that the EPROM needs.

The triacs are driven by PNP emitter followers; while this simplifies board layout (as no base resistors are required), it confuses things slightly as the triacs are then switched on by a zero output from the EPROM. This isn't such a bad thing as erased EPROMs are full of FFs (all outputs high) so this means that an unprogrammed location turns all the lights off.

The triacs are triggered by a negative gate pulse. In this way less current is required to trigger them on (5mA as opposed to 10mA for a positive going gate pulse). The triggering current is actually 50mA; this is to ensure that the triacs turn on fully as quickly as possible. This is fairly

important as lamps can have a turn on surge current of up to 10 times the normal running current and the triac will only cope with this if it is fully turned on.

Connections are made to the main board using "Wafercon" terminals for the mains outputs and Minicon connectors and ribbon cable for the switch and LEDs. These are more reliable than soldering to the PCB as movement can easily break a solder joint. (Minicon & Wafercons are from MAPLIN).

The seven segment displays can be either common anode or cathode. The circuit diagram shows the common anode variety with the common display terminal connected to 5V and the switch common to 0V. For common cathode displays simply reverse these two connections.

The CB rig switch (SW2) comes from Ambit, their catalogue shows two types along with a connection diagram. One type produces a BCD output which is one less than the number displayed on the 7 segment displays — for this application, this is immaterial. The displays were mounted on a scrap

PARTS LIST

RESISTORS (all 1/4 W 5% except as indicated)

R1,R2	22k
R3,R12	47k
R4	2M2
R5	2M7
R6	68k
R7,R8,R9,R38	100k
R10	33k
R11	150k 1/2W
R13	150k
R14,R15	15k
R16-R29,R47-R54	330R (22 off)
R30-R37	22k x 8 SIL resistor
R39-R46	100R (8 off)
RV1	500k log

CAPACITORS

C1	3μ3F 6V3 tant
C2,C3	1μF 6V3 tant
C4	10nF Siemens PCB polyester
C5	2200μF 10V Electrolytic
C6	10μF 6V3 Tantalum

SEMICONDUCTORS

IC1	TL064
IC2	4520
IC3	4070
IC4	2716 450ns EPROM
IC5	74LS373
IC6	7805 1A 5V regulator
D1	1N4148
D2,D3,D4,D5	1N4001
Q1,Q2	BC184L
Q3-Q10	2N3702 (8 off)
SCR1-SCR8	TIC206D (8 off)
LED1,2	Seven segment LED displays (see text)
LED3-10	single LEDs to choice

MISCELLANEOUS

T1	6-0-6 V 6VA
SW1	SPDT switch
SW2	Rig Switch — see text
FS1	13A fuse & holder
PCBs; lightholders; connectors to suit; IC sockets as required; crystal microphone	

piece of veroboard which was fixed to the front panel, and the interwiring between the displays and the switch was done using the 330 R resistors and insulating sleeves. The switch is intended to be PCB mounting but was used mounted on the front panel and connections were made by soldering wires to the tags.

The rectifier diodes and capacitor were mounted on another piece of veroboard fixed next to the transformer.

Both outputs from the sound-chase/oscillator board are taken to an SPDT switch, from which the common terminal goes to the clock input on the main PCB. 5V and 0V power supply wires are taken from the main PCB to the sound-chase/oscillator board. All

SEQUENCE	ADDRESS	CODE
40	1460	FF
39	1470	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
38	1480	00 FF
37	1490	FF 00
36	14A0	FF FF FF 00 FF FF FF 00 FF FF FF 00 FF FF FF 00
35	14B0	F0 0F
34	14C0	F0 FF 0F FF F0 FF 0F FF F0 FF 0F FF F0 FF 0F FF
33	14D0	C3 3C
32	14E0	AA 55
31	14F0	AA FF 55 FF AA FF 55 FF AA FF 55 FF AA FF 55 FF
1500 - 156F FF		
30	1560	7F DF BF EF DF F7 EF FB F7 FD FB FE 00 FF 00 FF
29	1570	7F 5F 57 55 54 50 40 00 80 A0 A8 AA AB AF BF FF
28	1580	7F DF F7 FD FE FB EF BF 7F DF F7 FD FE FB EF BF
27	1590	7F 5F 57 55 45 05 04 00 80 A0 A8 AA BA FA FB FF
26	15A0	7F DF F7 FD BF EF FB FE 7F DF F7 FD BF EF FB FE
25	15B0	FC F3 CF BF 00 FF 00 FF 3F CF F3 FC 00 FF 00 FF
24	15C0	E7 C3 81 00 18 3C 7E FF E7 C3 81 00 18 3C 7E FF
23	15D0	E7 C3 81 00 81 C3 E7 FF E7 C3 81 00 81 C3 E7 FF
22	15E0	E7 C3 81 00 18 3C 7E EE 7E 3C 18 00 81 C3 E7 FF
21	15F0	7E BD DB E7 E7 DB BD 7E 7E BD DB E7 E7 DB BD 7E
1600 - 165F FF		
20	1660	7E BD DB E7 7E BD DB E7 7E BD DB E7 7E BD DB E7
19	1670	F0 0F F1 8F F3 CF F7 EF F0 0F F8 1F F0 3F FE 7F
18	1680	7F FE BF FD DF F8 EF F7 7F FE BF FD DF F8 EF F7
17	1690	7F FE BF FD DF FB EF F7 7F FE BF FD DF FB EF F7
16	16A0	0F 87 C3 E1 F0 E1 C3 87 0F 87 C3 E1 F0 E1 C3 87
15	16B0	3F 0F 03 00 00 F0 FC FF 3F 0F 03 00 00 F0 FC FF
14	16C0	3F CF F3 FC 3F CF F3 FC 3F CF F3 FC 3F CF F3 FC
13	16D0	FC F3 CF 3F FC F3 CF 3F FC F3 CF 3F FC F3 CF 3F
12	16E0	77 88 DD EE 77 88 DD EE 77 88 DD EE 77 88 DD EE
11	16F0	EE DD 88 77 EE DD 88 77 EE DD 88 77 EE DD 88 77
1700 - 175F FF		
10	1760	7F F7 8F 8F 8F DF FD EF FE 7F F7 8F 8F 8F DF FD EF FE
9	1770	7F 3F 1F 0F 07 03 01 00 80 D0 E0 F0 F8 FC FE FF
8	1780	FE FC F8 F0 E0 C0 80 00 01 03 07 0F 1F 3F 7F FF
7	1790	7F 3F 1F 0F 07 03 01 00 FF 7F 3F 1F 0F 07 03 01
6	17A0	FE FC F8 F0 E0 C0 80 00 FF FE FC F8 F0 E0 80 A0
5	17B0	7F 8F DF EF F7 FB FD FE FE FD FB F7 EF DF BE 7F
4	17C0	FC F9 F3 E7 CF 9F 3F 7E FC F9 F3 E7 CF 9F 3F 7E
3	17D0	7E FE FC FD F9 FB F3 F7 E7 EF CF DF 9F BF 3F 7E
2	17E0	7F BF DF EF F7 FB FD FE 7F BF DF EF F7 FB FD FE
1	17F0	FE FD FB F7 EF DF BF 7F FE FD FB F7 EF DF BF 7F

ALL REMAINING LOCATIONS - FF

Table 1 Suggested EPROM contents.

the inter-PCB connections are shown on the diagram. The use of D-type sockets to connect the lights to the controller box is not recommended — you may get a nice display of pyrotechnics as the wires touch together but the triacs will blow faster than any fuse in the circuit and remove the tracks from the PCB. Use larger sockets as the McMurdo types which also have a retaining clip.

Setting-up

There are no adjustments to be made to the circuit — just connect to the mains (carefully), stand well back and switch on. If you get a flash of light from the PCB then

you had a short circuit and now your probably haven't much of a PCB left. On the other hand, if nothing happens first check that the switch is not set to 40 (this is all light off). If there are still no lights, check that there is 5V on

BUYLINES

The rig switch is available from Ambit; the suggested connectors are available from Maplin (although substitute types could be used); shop around for the EPROM and buy the cheapest you can find — Rapid should be worth a look; and the PCB is available from our very own service.

PROJECT : Light Chaser

the ICs — pins 24 and 12 on the EPROM 16 and 8 on the 4520, 14 and 7 on the 4070 or 4 and 11 on the TL064. If not suspect a bad connection or faulty voltage regulator. Check also that there is a 50Hz high mark/space ratio waveform on pins 18 and 20 of the EPROM — if not check round the 4070.

When all is working, play a record with a strong beat and check that when the SPDT switch is on 'sound' the lights change with the beat and that the lights change at a constant rate adjustable by RV1 when the SPDT switch is set to 'auto'.

When poking around with your 'scope/multimeter, don't forget that the circuit is at live potential, better still, use an isolating transformer. (It's a good idea to keep one hand behind your back all the time — this considerably lessens the likelihood of receiving a fatal shock).

Make sure that you don't put the sequence switch too close to the microphone otherwise the unit will respond to the clicks made by the switch when you change the

sequence, and, as these are quite loud the unit will take a couple of seconds before it starts sound-chasing again — this is due to the slow decay on the soundchase circuit.

EPROM Programming

Each sequence lasts for 16 bytes, a zero corresponds to on and 1 to off hence EC (hex) = 11101100 (binary) = lights 1,2 and 5 on, lights 3,4,7 and 8 off.

The starting address is 16 times the 1s complement of the output from the switch (see PROM dump if confused). This is because the switch is connected between the address line and 0V with a pull-up to 5V so that the output of the switch is inverted. This is to maintain compatibility with Schottky PROMS on which the address lines can be pulled up to 5V with a much higher value/resistor than down to 0V.

Modifications

Here is a list of possible enhancements:

1. Using a Schottky (fusible link) PROM. The type required is

875191. A slight modification has to be made to the PCB. Cut the track that connects pin 18 to pin 20 on the EPROM and connect pin 18 to pin 19 (a good big blob of solder will do).

2. Using the rest of the memory. Address line A10 is normally tied to 5V. This means that only the top 1024 bytes of memory are used (from 400 hex to 7FF hex). To use the other 1024 bytes cut the track between pins 19 and 21 on the EPROM and connect pin 19 to a SPDT switch which can connect pin 19 to either 0V or 5V (don't leave it floating). This is slightly more tricky on the bipolar PROM as A10 is pin 21. Cut the track at both sides of pin 21 and connect pins 18/19 (you connected them together above) to 5V. Connect the switch (as above) to pin 21.

3. If you want to use more than 375 Watts per channel: (a) Use heatsinks for the triacs, or if you are using spotlamps, use TIC226D instead; (b) Reprogram the EPROM so that the number of lights on at any one time cannot exceed 3000W (otherwise you'll blow the mains fuse).

ETI

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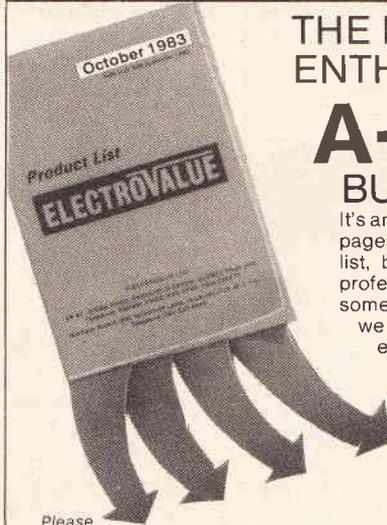
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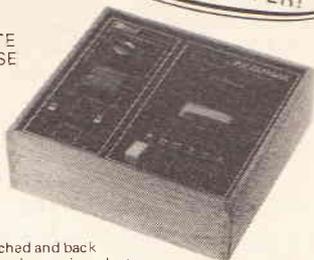
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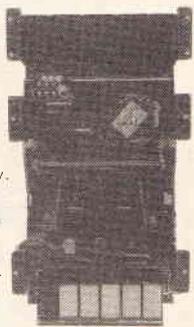
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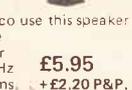
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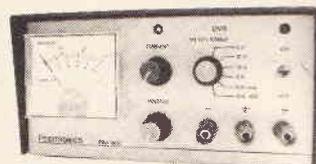


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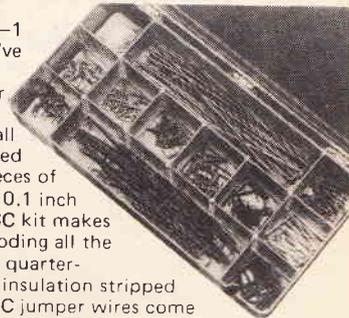
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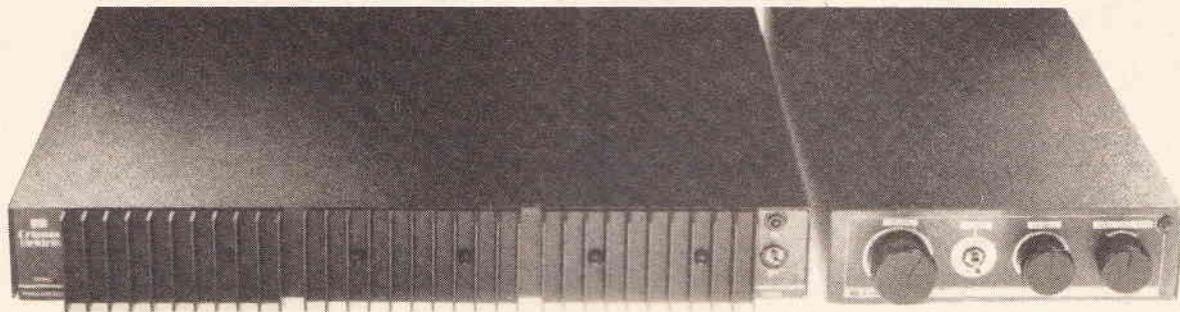


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REVIEW: ALTAI CAPACITANCE METER

Do you ever need to check capacitance? Vivian Capel reviews a meter that takes the misery out of measurement

Who wants to measure capacitors? Many amateur electronic enthusiasts and some professional technicians too, go through life without making a single measurement of capacitance and seem little the worse for it. After all, if you suspect a capacitor in a circuit, you just change it, if the fault clears well and good, if it doesn't you look elsewhere.

Capacitors can be the most troublesome of the passive elements in any circuit — surpassed only by connectors and dry joints as a source for trouble. You may even find it well worthwhile to check all new capacitors as a matter of routine — particularly when prototyping, when it is important to rule out possible sources of malfunction at an early stage.

There are many other situations where capacitance measurement can be very helpful, if only it was as quick and straightforward as measuring resistance. The answer is to invest in a direct reading capacitance meter. There are a few models about, although they are not as common as the bridge. One of the latest to appear is the ALTAI DM-6013, supplied by Semiconductor Supplies International Ltd., 128/130 Carshalton Road, Sutton, Surrey, at a cost of £49.50 plus VAT.

A Closer Look

The Instrument is housed in a plastic case sized $7 \times 3\frac{3}{4} \times 1\frac{1}{2}$ inches, which feels sturdy to handle, not like some instrument cases. It can be supported on the workbench at an angle by means of a pull-down stand at the back.

It doesn't take that close a look to see that the display is a digital LCD read-out giving half-inch high figures. Now I am not over-enthusiastic about LCD displays in spite of their power economy, as the readability is not always what it should be. I have no grumbles with this one though, the $3\frac{1}{2}$ -digit read-out comes with bold black figures against a silver-grey background. I found it readable from most angles and in poor light.

A striking feature of the meter is its range. It will measure from 0.1 pF up to 2000 μ F, which when you think about it is a staggering ratio of 1 : 2¹⁰. The low end of this range does permit some interesting experiments in circuit stray-capacity.

The eight individual ranges are selected by interlocking push-buttons arranged down the left-hand side of the instrument. These advance in value in increments of ten, from the lowest at 200 pF to the highest 2000 μ F. Resolution is from 0.1 pF at the lowest range to 1 μ F at the highest.

Specified accuracy is 0.5% on all ranges except the highest for which it is 1.0%. If at any time the accuracy falls outside of those tolerances, the instrument can be recalibrated by the user by means of an internal preset and a capacitor of known value, preferably a large value near the maximum for the particular range.

The instruction booklet describes how to do this, but

owing to the inherent stability of the LSI circuitry it should rarely be necessary. If much hard use is envisaged though, it might be prudent to anticipate recalibration, by selecting a suitable capacitor with a low temperature coefficient and recording its measured value with the new instrument. This could subsequently be used as the standard for accuracy checks and recalibration.

Apart from the range switches the only other controls are the on/off switch and a set-zero knob. This latter was the cause of some initial disappointment as I imagined having to fiddle with it each time a range was changed or a measurement made. I was relieved to find I was wrong, as this would have been as irksome as finding the null on a bridge. The control has an adjustment range of ± 20 pF and therefore is significant only on the bottom two ranges, especially the lowest. Its purpose is to cancel the capacitance of the test leads when making low capacitance measurements.

The instrument applies a small excitation voltage of 2.8V maximum to the capacitor under test. The bottom five ranges function on a frequency of 800 Hz, but for the



FEATURE : Review

higher ranges, the frequency is lowered to 80 Hz (200 μ F range) or 8 Hz (2000 μ F). Sampling of the capacitance takes place every half-second, so any variations change the read-out at this rate.

Polarity of electrolytic and tantalum capacitors must be observed, this being indicated by the colour of the leads and sockets (red and black). It is essential to discharge any capacitor before connecting it to the meter, otherwise damage could be caused: there is a 200 mA fuse at the input, but it is wise not to rely on this.

Powering is by a PP3 battery which lasts for 100 hours operation or 200 hours in the case of an alkaline type. When the battery voltage falls to 6.7-7.0V, the legend "LOBAT" appears in the top left-hand corner of the LCD display. When this happens there is still some 20% of the battery life left and several hours use, so this is in the nature of an early warning rather than an instruction for immediate replacement. It should not be used for too long beyond this though, otherwise the accuracy will fall with subsequently falling voltage.

In Use

How then did it perform? A good capacitor gave a stable reading within a couple of seconds of being connected. The zero setting on the lowest range was rather touchy, but this is to be expected when dealing in tenths of a picofarad. Movement of the test lead or even one's hand can give a change of capacitance.

On my first introduction to the instrument I felt it was a pity not to have included a leakage test. However, after using it to measure quite a number of capacitors of various types and sizes I found that there is, in fact, a way of testing for leakage. Digit rounding apart, leaky capacitors will give higher readings on the higher range(s) than on the lower. Large leakages (and dead shorts) will return the over-range "1" reading on all ranges.

I also noticed that some capacitors did not give a stable reading, usually yielding a slowly increasing one. Whilst this is not that bad a behaviour for an electrolytic (typical tolerance -50% or +100%), it is bad news for an unpolarised type, and resulted in a fair number of my stock capacitors being consigned to the bin! Also ditched was a smaller number that gave a continual up and down variation.

Lead Testing

A job that I discovered I could do with the test meter was to find the approximate position of an open circuit in a faulty audio lead, so easing the job of repair (OK, I know that if it's gone O/C once, it's likely to go again somewhere else, and the best thing to do is to dump it, but there are occasions when this isn't possible...).

When a connecting lead goes O/C, it is almost always near the connector, because there is more flexing there. But at which end? Well it's easy enough to tell with the meter — simply check the inter-conductor capacitances at both ends (ie. centre to screen); the end with the lower capacitance is the one with the fault near it. In the rare event of a break near the middle, this will show up as approximately equal to the ratio of the two lengths to the break.

Conclusion

This is an excellent instrument which does its job well, and which you tend to use more and more until you wonder how you managed without it. It is accompanied by a well-written and informative instruction booklet that contains much useful data including a table listing the various types of capacitor and their characteristics.

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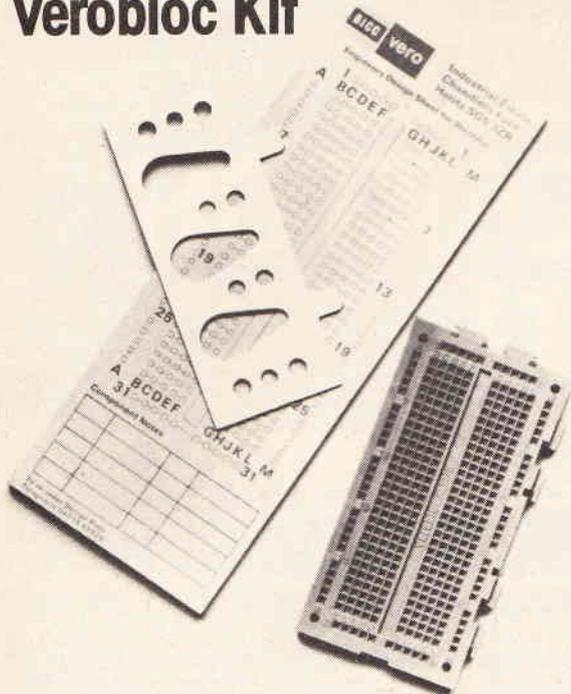
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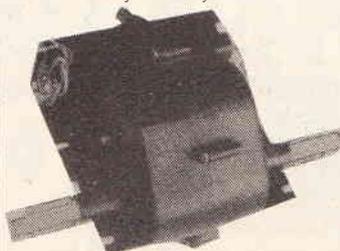
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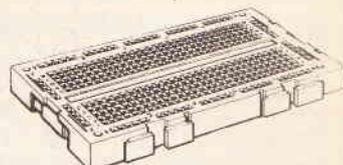
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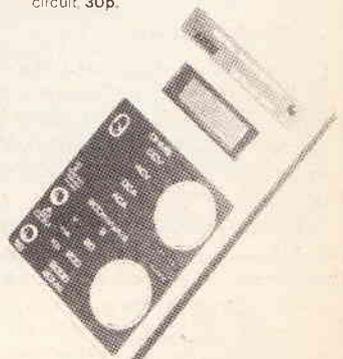
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MODULAR PREAMPLIFIER

If walls had ears... they'd certainly appreciate ETI's audio building blocks. Barry Porter surveys the ground and comes up with a few plans.

Pre-amplifiers come in all shapes and sizes, yet all are designed to perform the same basic function — to select the output of a given signal source and apply it to a power amplifier at a level that can be adjusted to give the required power output.

It is evident that no pre-amplifier on the market satisfies everyone's requirements. Some people must have tone controls while others will not entertain them at any price. Some want moving coil cartridge inputs, others do not... What is really required is a pre-amplifier that can be constructed to suit individual needs — a sort of audio Lego kit!

After much deliberation it was decided to design just such a unit, using a mother board system with the active circuitry on individual plug-in boards. This makes it possible to build a pre-amplifier to virtually any configuration by just changing the mother board, which consists primarily of busses and interconnections between the boards carrying the signal circuits.

To make this system as flexible as possible, the individual building blocks have been broken down into the following categories:-

1. Disc amplifier (Moving coil or magnet)
2. Unbalanced output stage (With provision for active balance control)
3. Balanced output stage
4. Tone Controls
5. Headphone Amplifier
6. Muting Relay Control
7. Power Supply

The first pre-amplifier to be described will use units 1, 2, 6 and 7, so a description of these circuits will be given first, followed by details of how to link them together to make a pre-amplifier that will out-perform many manufactured units that cost the proverbial arm and a leg.

It will be noticed that all signal circuitry is based on the use of operational amplifiers, and as this may raise a few eyebrows, a short sermon in defence of this practice is called for... In the early days of integrated circuits, there was created a device known as the 741. Although this humble chip performed well at low frequencies, its limitations at the upper end of the audio spectrum rightfully gained it a reputation for sonic nastiness. Fortunately, progress and evolution have been quite active, and about five years ago a far superior device emerged. Called the 5534, this quickly became the standard IC of the professional audio industry, which consumed them in great quantities. So it is safe

to assume that any recent recording has passed through quite a number of these devices — as many as two or three hundred in the case of a multi-tracked original — so no excuses are offered for using a few more in the reproduction chain.

Perhaps comment should be passed on one or two other practices. Following a recent discussion with Martin Colloms, the author carried out some tests which showed that certain types of capacitor can degrade the sound of audio circuits. In particular, the common polyester types proved to be unsatisfactory, as did the standard type of aluminium electrolytic, especially when used without a defined polarizing voltage. For this reason, all small value capacitors should be either polystyrene or polycarbonate (polypropylene are marginally better than polycarbonate, but are difficult to obtain, expensive and very large in size) and the inter-stage and feedback shunting electrolytics should be of non-polarized

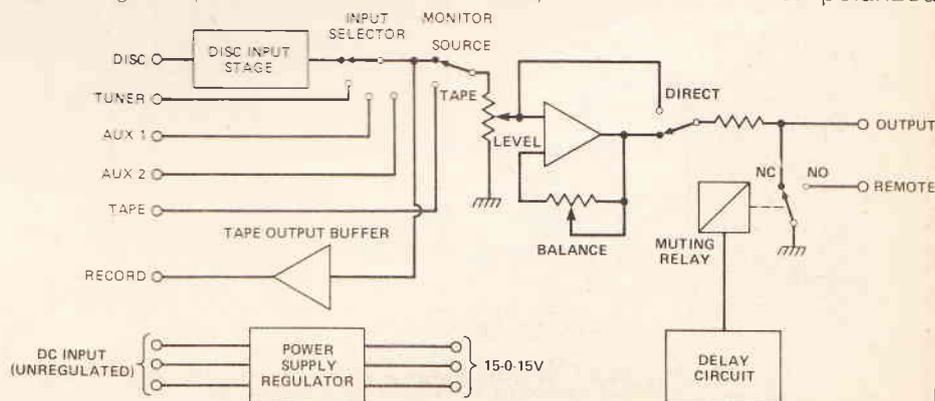


Fig. 1 Block diagram of the basic preamplifier.

construction and should be paralleled with a smaller value polycarbonate, which helps to flatten the high frequency impedance curve.

With that little lecture out of the way, we come to the design of the pre-amplifier, shown in block diagram form in Figure 1. It consists of a disc amplifier stage which may be for moving coil or moving magnet cartridges, input selector switch, level control, active balance control stage and muting circuit. A switch marked 'Direct' may be used to bypass the balance stage, so that if a source with sufficient output capability, such as a Compact Disc player, is connected to an auxiliary input, it may be routed to the power amplifier with only the ganged level control in its path. When the balance stage is in circuit, the input sensitivity of the tuner and auxiliary inputs is 200 mV for 1.0 V output. The input sensitivity of the disc amplifier can be set to match the cartridge in use, and the input loading may be set to any suitable value of resistance and capacitance. The overload margin of the disc stage is 32dB at all frequencies which should be ample, even with the hot cuts that are sent to annoy us. On tuner and auxiliary there will be no overload problems, as the level control is placed in front of the active circuitry. A note of warning here though — it has been found that the best value of level control is 10k ohms, as this is not likely to cause problems when the direct path is used. Unfortunately, some equipment requires a greater load than this for correct operation, so the choice of level control value should be made with

due consideration to this.

Now to the individual circuits that are to be used, starting with the most critical which, of course, is also the most difficult to design and engineer.

Disc Amplifier Stage

In simple terms, this circuit has to amplify the output of a pick-up cartridge to a higher, more manageable level, and at the same time apply equalisation to the RIAA standard, this being defined by three time constants: 3180 μ s and 75 μ s (corresponding to 50.05 Hz, 500.5 Hz and 2.122 kHz).

The amount of amplification will depend upon the output voltage of the cartridge in use, moving coil types typically requiring some 20-25 dB more gain than moving magnets. To give some idea of the magnitude of the problem, a moving coil cartridge with a nominal output of 0.2 mV at 1 kHz requires amplification by more than 9000 at 20 Hz to give 200 mV at the amplifier output. The RIAA equalisation curve which, relative to 1 kHz, rises to +19.27 dB at 20 Hz and drops to -19.62 dB at 20 kHz, may be obtained in a number of ways. Active feedback around a single amplifier stage is the most popular — possibly because it gives a good specification on paper, particularly in respect of overload margin, which is constant with frequency. This configuration has some drawbacks, usually caused by the amplifier output stage having to drive the very capacitive feedback network. Another type of circuit that has become quite popular uses a passive network between two stages of

amplification. Subjectively, this method proved quite successful, but it suffers from inferior noise performance and greatly reduced high frequency overload characteristics.

The circuit to be described may be termed a 'hybrid', in that it has part active and part passive networks. In order to keep noise to a minimum when using a moving coil cartridge, the technique of forming the input stage from several transistors in parallel has been employed. The LM394 integrated circuit contains 100 individual devices divided into two sets of 50 each. By joining the connecting leads of each set together, all 100 transistors are used. When the circuit is operated with a moving magnet cartridge, the LM394 can be replaced by a similar dual device containing a pair of normal, bi-polar transistors. Not only does this help the economics, it should also be quieter as a better impedance match is likely.

Figure 2 shows the complete disc input circuit, and Table 1 gives the component changes necessary in order to adjust the input sensitivity to allow operation with a wide range of cartridges. The input components, R1 and C1, should be chosen to accurately load the cartridge in use, but as a general rule should be 100R and 22n for moving coil cartridges and 47k and 220 pf for moving magnets.

The operation of this circuit is quite straightforward. The LM394 is set at 2mA collector current, which causes the inverting input of IC2 to be at 6.3V. The non-inverting input is therefore biased to be at the same voltage. Feedback is applied to the

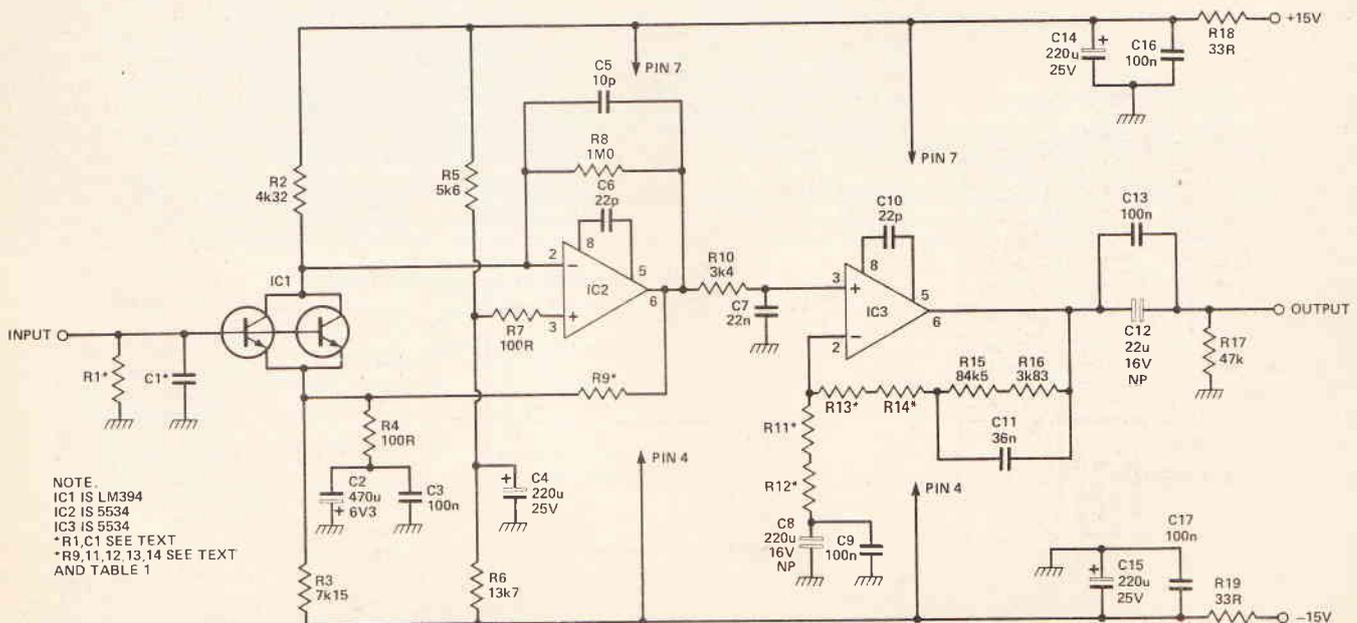


Fig. 2 Circuit diagram of the disc preamplifier stage.

PROJECT : Modular Preamplifier

emitter of the LM394 by R9, which, together with the 100 ohm shunt resistor R4, sets the gain of the first stage. This may be calculated from:

$$A(\text{dB}) = 20 \log \left(1 + \frac{R9}{100} \right)$$

An important consideration at this point is signal overload. This is measured by applying a range of frequencies that have been subjected to inverse RIAA equalisation, and is stated as the amount that the input level can be increased above its nominal rating before the output signal is clipped or severely distorted. As the rated output of the disc amplifier is 200 mV and clipping occurs at about 8.0 V, the overload margin should be:

$$20 \log \left(\frac{8}{0.2} \right) = 32\text{dB}$$

at all frequencies. As no equalisation takes place in the first stage, care has to be taken to ensure that high frequency overload does not occur — remember that the 20 kHz input level will be at +19.62 dB — which means that the rated input level multiplied by the first stage gain must not exceed $(19.62 + 32.0) = 51.62$ dB below 8.0 V, or about 21.0 mV. A quick calculation based on the gain settings given in Table 1 shows this to be the case, and consequently a full 32.0 dB overload margin will be maintained throughout the audio spectrum.

Following the input stage, a

passive network provides the $75\mu\text{s}$ time constant ($3400 \times 22\text{n} = 74.8\mu\text{s}$) and a network in the feedback circuit of IC3 gives the $3180\mu\text{s}$ and $318\mu\text{s}$ breakpoints. The 36n capacitor, C11, with R15+R16 fix the first point ($36\text{n} \times (84.5\text{k} + 43.83\text{k}) = 3179.88\mu\text{s}$), and the same capacitor together with the series-parallel combination of R13, 14, 15 and 16 fix the second. Table 2 gives details of the RIAA characteristic over a range of frequencies so that performance of the disc stage may be checked for accuracy, which, with the specified components will typically be to within 0.1 dB between 20 Hz and 20 kHz. Stray capacitance may affect the extreme high frequency response, but the prototype

Input	1st Stage Gain	R9	R11	R12	R13	R14
0.1 mV	Moving coil	11k0	536R	21R5	8k87	412R
0.2 mV		5k6	536R	21R5	8k87	412R
0.3 mV		3k65	536R	21R5	8k87	412R
0.5 mV		2k15	536R	21R5	8k87	412R
2.0 mV	Moving magnet	887R	909R	82R5	8k06	806R
3.0 mV		562R	909R	82R5	8k06	806R
5.0 mV		301R	909R	82R5	8k06	806R
8.0 mV		7.96 dB	150R	909R	82R5	8k06

Table 1 Component values for the disc amplifier stage.

f(Hz)	dB	f(Hz)	dB	f(Hz)	dB
0	+19.911	100	+13.088	10k	-13.734
5	+19.868	200	+8.219	15k	-17.157
10	+19.743	500	+2.648	20k	-19.620
20k	+19.274	1k	0 (Ref)	30k	-23.117
30	+18.593	2k	-2.589	50k	-27.541
40	+17.792	3k	-4.740	100k	-33.556
50	+16.946	5k	-8.210		

Table 2 RIAA equalisation characteristics of the disc amplifier.

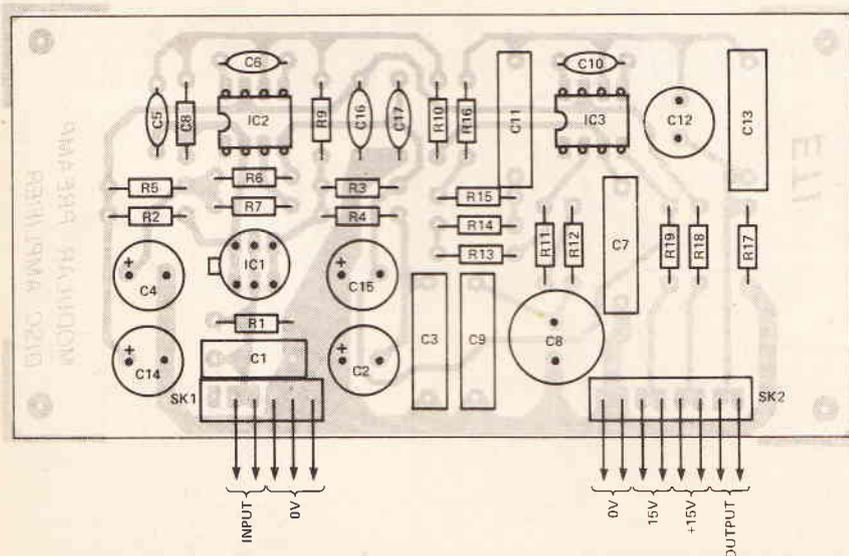


Fig 3 Component overlay of the disc amplifier PCB.

PARTS LIST

Disc Amplifier (one channel only)

Resistors (all 1% metal glaze or metal film)

R1	see text
R2	4k32
R3	7k15
R4, 7	100R
R5	5K6
R6	13k7
R8	1M0
R9	see text
R10	3k4
R11, 12, 13, 14	see text
R15	84k5
R16	3k83
R17	47k
R18, 19	33R

Capacitors

C1	see text
C2	470u 6V3 radial electrolytic
C3, 9, 13	100n 250v polycarbonate
C4, 14, 15	220u 25V radial electrolytic
C5	10pf 160V 2½% polystyrene
C6, 10	22pf 160V 2½% polystyrene
C7	22n 63V 1% polystyrene
C8	220u 16V non-polarised electrolytic
C11	36n 63V 1% polystyrene
C12	22u 16V non-polarised electrolytic
C16, 17	100n 100V polyester

Semiconductors

IC1	LM394
IC2, 3	NE5534

Miscellaneous

SK1	6 way PCB socket
SK2	8 way PCB socket
PCB:	

was still accurate to within 0.5 dB at 100 kHz, which should not cause undue concern. There is no particular merit in having equalisation this precise, but as the network design is so simple, there seems no point in not keeping things as tidy as possible. (For anyone interested, the author can provide a T159 programme that calculates the RIAA deviation, at any frequency, to an accuracy of 8 decimal places!)

Unbalanced Output Stage

This stage, which incorporates an active balance control, is placed immediately after the main level control. The same circuit is used, without the balance facility, as a tape recorder output buffer. As shown in Figure 4, it has been designed to allow a limited amount of imbalance between channels — a maximum of 10 dB — with sufficient gain to raise the 200 mV input signals to the 1.0 V rated output of the pre-amplifier. The balance control operates by changing the amount of feedback around the amplifier stage. This method preserves a good signal to noise ratio and overload margin while giving a well controlled image shift. Table 3 shows the amount of imbalance between channels at different positions of the control, and it will be seen that the calibrations are typically accurate to within 0.5 dB.

Note that the output capacitor of the stage is within the main feedback loop of the amplifier. This is done for two reasons — it helps to counteract any effects introduced by the capacitor, and it avoids the danger of any DC voltage appearing on the control potentiometer which would introduce noise whenever the control was operated. There have recently been some suggestions that all passive components, such as switches, connectors and potentiometers should be provided with a DC bias voltage, as this helps to provide clean contacts for improved signal transmission. The theory behind this may be well founded, but long experience with recording studio mixing consoles, where it is quite common for DC to appear in all sorts of unwanted places, has shown that the working life of components subjected to this treatment is drastically reduced, so they need replacing much earlier than similar ones that have remained free of DC voltages.

The same stage is also used as a tape recorder buffer, with points A and B linked together and changed values for R4, R6 and C2. R4 should

Control Calibration	Imbalance
2	1.81 dB
4	3.67 dB
6	5.61 dB
8	7.69 dB
10	10.01 dB

Table 3 Characteristics of the balance control

Record Output Level	Gain	R6	R4	C2
499.5 mV	7.95 dB	1k50	1k	100u
1.0 V	13.99 dB	4k02	1k	100u
1.2 V (0 VU)	15.72 dB	5k11	1k	100u

Table 4 Component values for the tape output buffer.

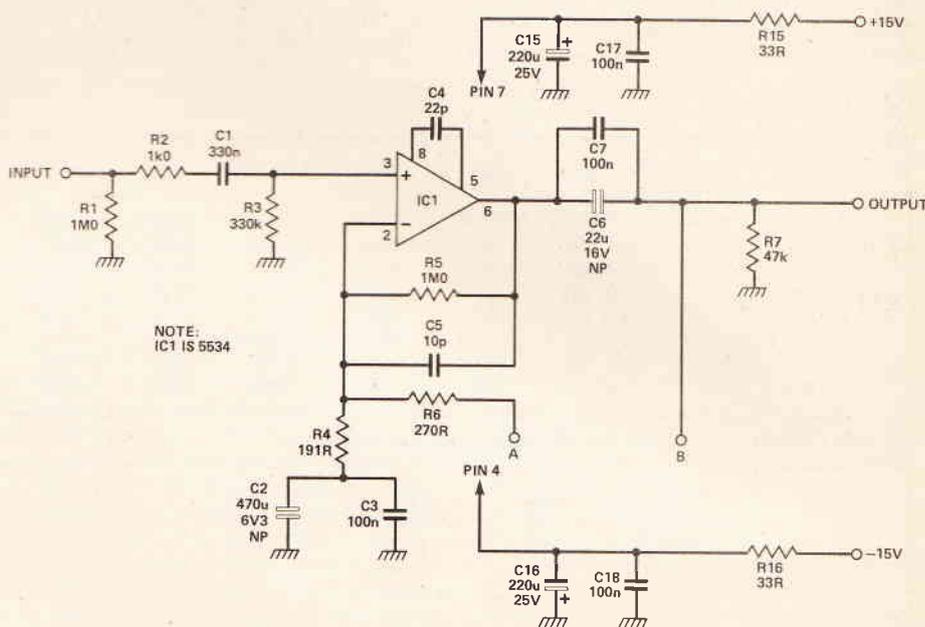


Fig. 4 Circuit diagram of the unbalanced output stage.

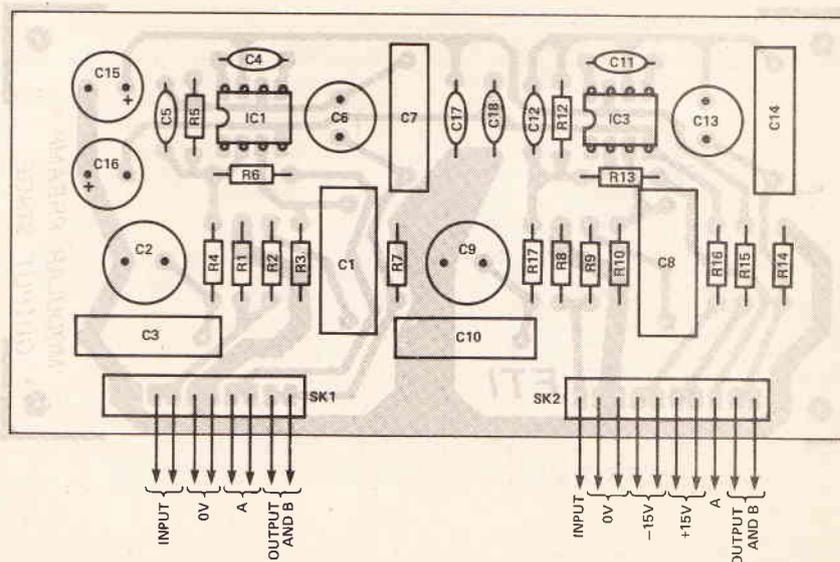


Fig. 5 Component overlay of the unbalanced output stage PCB. Note that this board is for stereo operation and therefore carries two complete output stages.

PROJECT : Modular Preamplifier

become 1k ohm, C2 should be changed to 100µ 16V non-polarized and R6 chosen to give the required output level according to Table 4.

The importance of buffering the tape recorder output, as shown in

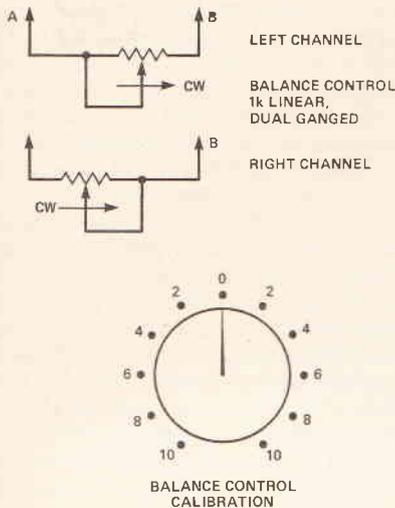


Fig. 6 Balance control connections and calibration.

PARTS LIST

Unbalanced Output Stage

Resistors (all 1% metal glaze or metal film)

R1, 5, 8, 12	1M0
R2, 9	1k0
R3, 10	330k
R4, 11	191R
R6, 13	270R
R7, 14	47k
R15, 16	33R

Capacitors

C1, 8	330n 250V polycarbonate
C2, 9	470u 6V3 non-polarised electrolytic
C3, 7, 10, 14	100n 250V polycarbonate
C4, 11	22pf 160V 2½% polystyrene
C5, 12	10pf 160V 2½% polystyrene
C6, 13	22u 16V non-polarised electrolytic
C15, 16	220u 25V radial electrolytic
C17, 18	100n 100V polyester

Semiconductors

IC1, 2 NE5534

Miscellaneous

SK1, 2 10 way PCB sockets
PCB:

Figure 1, must be stressed. Without the buffer stage, the recorder input would be connected directly to the main signal path of the pre-amplifier. There is nothing wrong with that, provided the recorder is switched on, but some recorder input circuitry can appear very non-linear when it is not powered, and this could introduce high levels of distortion into the pre-amplifier. The buffer stage also presents the opportunity to introduce gain into the record chain, and avoids the danger of a recorder with a low input impedance loading the output of any other piece of equipment that is connected to the pre-amplifier.

The output levels given in Table 4 should be suitable for most applications, but any other gain setting can be used, calculating R6 from:

$$R6 = 1000(G-1).$$

Muting Relay Control

Although not absolutely essential, this simple circuit will more than pay for itself the first time you switch your equipment on in the wrong sequence and it saves your speakers, eardrums or central nervous system from instant destruction. The circuit (Fig. 7) controls a relay which, in its relaxed state, shorts the main signal outputs to earth via R4 and R5. This means that the signal does not normally pass through the relay contacts, and is therefore unaffected by their presence. When power is applied to the pre-amplifier, the relay remains relaxed until the voltage on the base of Q1 has risen to 0.6V when Q1 and Q2 turn on, opening the relay contacts that are shorting the signal to earth. The 560 ohm resistors are in series with the output signal to prevent the output amplifier stages from being overstressed by the short circuit condition. Note that power to the relay is

supplied from both rails, so that if one rail is not present, the output will remain muted. This eliminates a situation where, if the negative rail has failed, a 5534 will sometimes oscillate at a frequency approaching that of Heathrow Air Traffic Control, causing havoc to tweeter voice coils, bats and Boeing 747s.

The 6.8 V zener diode ZD1 will normally be connected to earth at a convenient point but, if headphone amplifiers are to be fitted, it may be earthed via the break contacts on the phones jack socket. Insertion of a jack plug will then de-energise the relay so that the main outputs are muted, and also apply power to the headphone amplifiers so that the programme is played only through the headphones. The relay is also used to provide remote switching for use with active speakers and other ancillaries.

Power Supply

This is based on IC Regulator types 7815 and 7915 (Fig. 8). Ideally, these should be mounted within the pre-amplifier with the transformer and main smoothing capacitors separately housed and placed some distance away to minimize the danger of hum pick-up. If the complete supply is contained within the pre-amplifier case, it is essential that a toroidal mains transformer is used, as the problems of screening will be considerably reduced.

Although the power supply appears simple, one or two tips may be in order. The 0.1µf capacitors, C4, 5, 8 and 9, should be mounted as close to the regulators as possible, and care should be taken to establish a single earth path from the transformer centre tap to the OV output. Contact suppressors should be connected across the mains switch as shown. The power 'On'

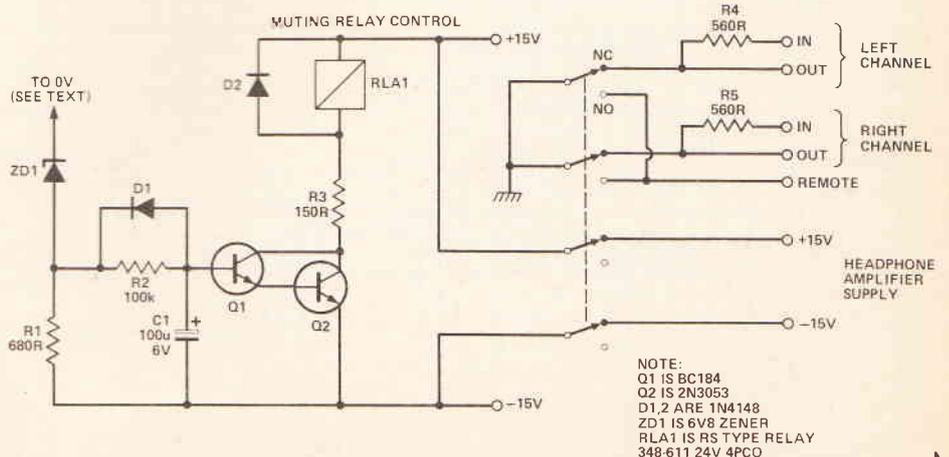


Fig. 7 Circuit diagram of the muting relay control.

LED is connected between both stabilized rails so that it acts as an indicator that all is well in the power supply department. The regulators do not require heatsinks when only the basic unit is constructed, but if headphone amplifiers are included, IC1 and IC2 should be mounted on standard T0220 finned heatsinks, or attached to the metal chassis using the insulating washers supplied with the devices.

Construction

The individual 'building block' circuit boards should be fitted with interconnecting sockets which mate with matching plugs on the mother board. The contacts of the recommended connectors are on a 0.1" pitch so that if necessary, Vero board can be used for the mother board, and indeed, for the plug-in boards as well if you do not want to go to the expense of obtaining proper printed circuit boards.

Suitable cabinets are available from such suppliers as West Hyde

Developments and Maplin, who can also provide the front panel controls. There are no special requirements for these except that they are of a reasonable audio grade. The input selector switch, which needs to be a 2 pole 4 position type, should be purchased as a 4 pole variety so that each contact can be doubled up for reliability. It is not necessary that the switch contacts are gold plated, providing they have a good, firm wiping action, so any build-up of deposits is removed with each operation. The potentiometers should be good quality carbon or cermet types with multi-contact wipers. If they can be obtained, the special audio controls from the larger Japanese suppliers, such as Alps, are of very high quality, and are not expensive. It has already been suggested that the best value for the level potentiometer is 10k ohms, although if this is likely to cause loading problems, 25k is acceptable. It is worth remembering that the Japanese D law is preferable to

the usual logarithmic law, as it gives a much smoother control of the output. To avoid the image shifting with different settings of the level control, the two sections should be matched to within 1dB over most of their travel. The balance control should not suffer from this shortcoming, as linear potentiometers are normally made to tighter tolerances, but as a general rule, the better quality the component, the greater is the chance of accuracy.

If lever or toggle switches are used for the tape monitor and direct functions, these should have contacts that are suitable for low level audio use, and again, suppliers such as Alps seem to have got the problem licked. Phone sockets used for signal connections should preferably be gold plated, and must be isolated from the chassis. This can prove difficult if the rear panel is thicker than about 1.0 mm, as most available sockets do not have sufficient length of threaded bush to pass through a thick panel as well as the insulating

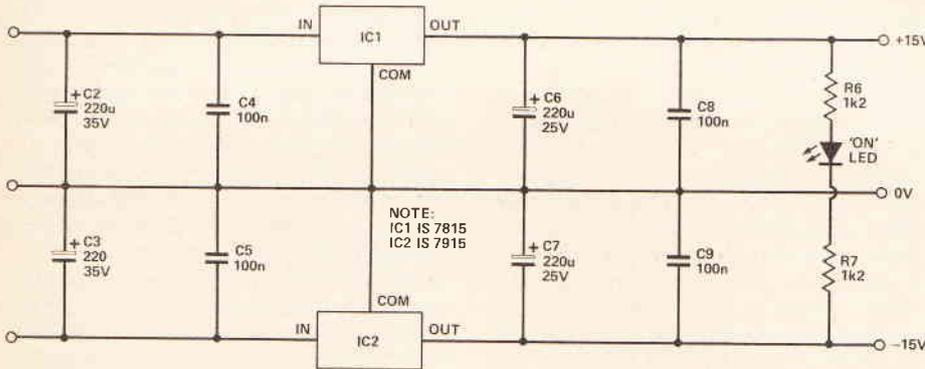


Fig 8. Circuit diagram of the power supply.

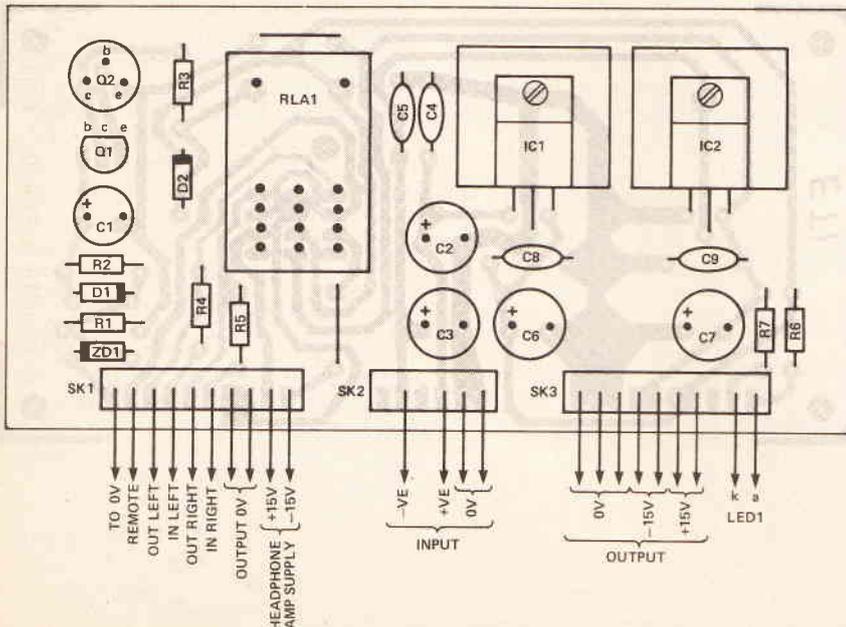


Fig 9 Component overlay of the power supply and muting relay control PCB.

PARTS LIST

Power Supply and Muting Circuit

Resistors

R1	680R 5%
R2	100k 5%
R3	390R 1W 5%
R4, 5	560R 1% metal glaze or metal film
R6, 7	1k2 5%

Capacitors

C1	100u 25v radial electrolytic
C2, 3	220u 35V radial electrolytic
C4, 5, 8, 9	100n 100V polyester
C6, 7	220u 25V radial electrolytic

Semiconductors

IC1	7815
IC2	7815
Q1	BC184
Q2	2N3053
D1, 2	1N4148
ZD1	6V8 400 mW zener

Miscellaneous

SK1,3	10 way PCB sockets
SK2	6 way PCB sockets
PCB: heatsinks and nuts, bolts, etc to suite (see text); 12V 185R 4 pole changeover relay, continental series.	

PROJECT: Modular Preamplifier

exercise until optimum earthing has been achieved, then install permanent wiring where necessary.

Once it's working, what can you expect? It is nice to report that the performance of the prototype was well up to expectation. Distortion was virtually unmeasurable, being equal to the test equipment residual on the auxiliary inputs (0.0018%), and well down into the noise on the moving coil inputs. Signal to noise of the moving coil stage was better than -75dB (A weighted, 0.5 mV input, 0.5 V output). The RIAA equalisation curve was within 0.15 dB between 20 Hz and 20 kHz, and crosstalk was better than -65 dB at 20 kHz and -83 dB at 1 kHz.

Subjectively, the unit sounds clean and analytical. Hum and noise never intrude and dynamics are handled with an ease that leads the listener to believe that it will never overload; in fact it is all that a good pre-amplifier should be, in that it is the quality of the source material that decides the quality of sound coming from the speakers.

BUYLINES

The PCB plugs and sockets are available from both Maplin and Ambient, although neither carries a full range so you might have to buy from both. The relay is available from Watford Electronics. Note that no provision has been made for the use of a relay socket, so if you prefer to use one you will have to adjust the pads on the PCB. You could, of course, use any other four pole relay with a coil operating voltage of 30V or less by adjusting the layout and the value of R3. Several different types of heatsink would be suitable or if you prefer, you could make your own quite simply. Some of the 1% tolerance resistances are in the E24 range which is widely available but others are in the E96 range which is not. If all else fails, most of the values

can be produced by placing two E24 values in series, and doing so will neither compromise the tolerance figure nor introduce extra noise. Maplin and Electrovalue supply non-polarised electrolytics but in axial, not radial, form, and again you might have to do a little juggling to get the right values. We are hoping to make a complete kit of parts for this project available, but were unable to make the arrangements in time for details to appear in this issue. Meanwhile, if any one out there can supply the 1% resistors and non-polarised capacitors, let us know and we'll give you a mention.

Note that the PCBs for this project will NOT be available through our PCB service.

The second part of this article in next month's ETI will contain details of the

mother board and the three remaining modules.

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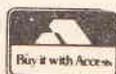
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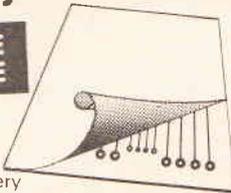


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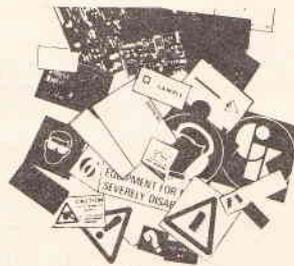
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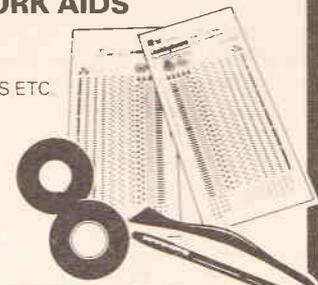


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TECH TIPS

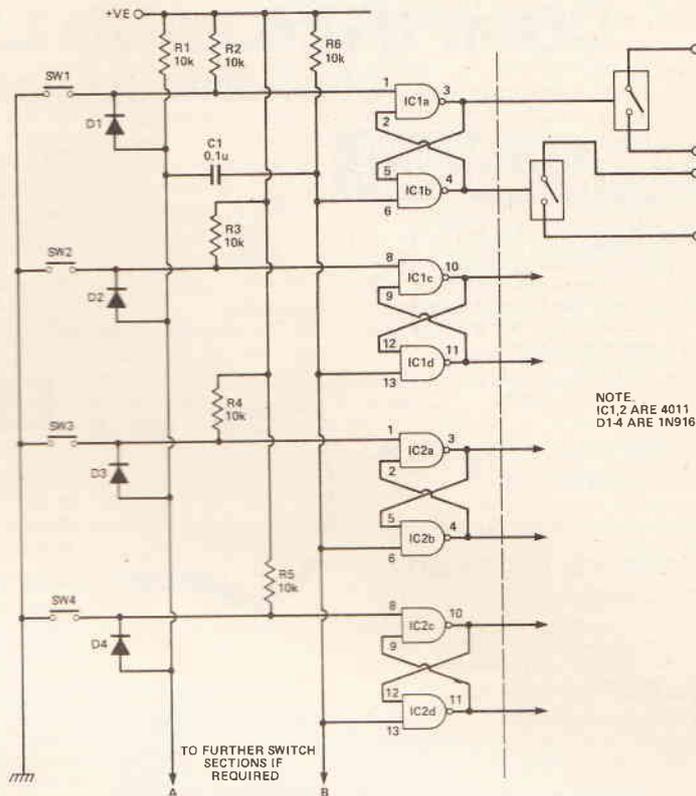
Latching Switches

Clive Pantrey,
Farnborough.

This circuit allows individual, momentary-action, push to make switches to be used in a ganged, latching mode for logic or low level audio signals.

When a switch is pressed the common reset line of all the latches sees a momentary ground, through C1 and its associated diode, this resets the previous selection and allows the selected output to latch.

A number of different devices could be connected to the latch outputs to provide various types of switches, bi-lateral switches are shown on the circuit. Further stages can be added to the bank as required, by connecting to points A and B.



Linear to Log Convertor

D. R. Fowness
Wolverhampton

This logarithmic generator utilises the inherent antilogarithmic transconductance of the transistor function, and works around a feedback circuit that balances the input current.

The input amplifier, IC1, ensures that the collector current of Q1 is equal to the input current. The reference current will be equal to the collector current of Q2. Transistors Q1 and Q2 should be a matched pair, and be mounted in thermal contact.

The voltage at the non-inverting input of IC2 will be:

$$V_{beQ2} - V_{beQ1}$$

but

$$V_{beQ1} = \frac{kT}{q} \times \log \left(\frac{I_c}{I_o} \right)$$

and

$$V_{beQ2} = \frac{kT}{q} \times \log \left(\frac{I_r}{I_o} \right)$$

so that the voltage at IC2 non-inverting input will be:

$$\frac{kT}{q} \log \left(\frac{I_r}{I_c} \right)$$

where

I_c = input current

I_r = reference current

I_o = reverse saturation current

T = temperature

k = Boltzman's constant

q = charge on an electron

At room temperature, kT/q is approximately 0.26 mV.

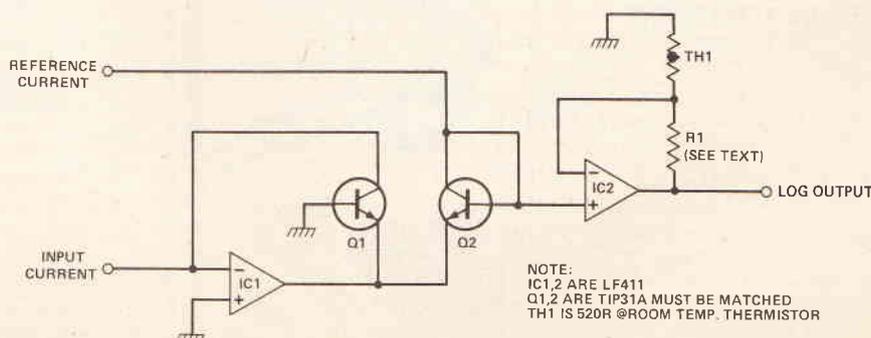
The scaling factor of amplifier IC2

(ie the gain) is given by $(R1+R2)/R1$. The scaling factor is equal to the number of output volts corresponding to one decade change of the ratio. R1 is the thermistor which should be chosen to compensate for any change in temperature and so maintain a constant gain.

The output voltage will be given by

$$\frac{(R1+R2)}{R1} \times 0.26 \log \left(\frac{I_c}{I_r} \right)$$

Note that all the logarithms are in base e, and not base 10!



De-Luxe AB Box

Marcus Valentine,
Stafford.

This Audio line signal routing device was designed for one of those guitarists who feel insecure unless they are surrounded by numerous effects boxes, but who wish to have more control over them collectively. It has two modes: single and dual.

In the single mode, depression of the footswitch noiselessly re-routes the signal path from going through chain A, to chain B, a chain being either a straight jack to jack lead, an effect, or a series of effects.

In the dual mode, the signal is re-routed through chain A followed by chain B, and on depression of the footswitch (here's the clever bit) is re-routed to chain B followed by chain A.

The two LEDs indicate the chain selected in the single mode, and in the dual mode the first chain.

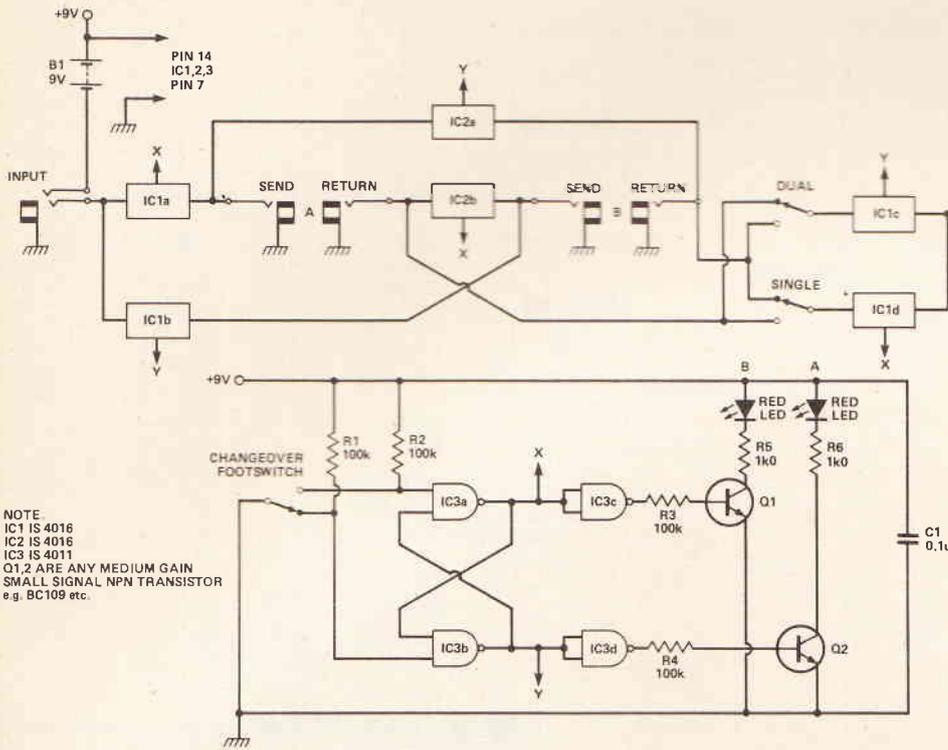
The flip-flop built around N1 and N2 ensures that the bilateral switches used change state cleanly and quickly, and more importantly, at the same time.

Current consumption, which is set mainly by the LEDs, is low enough to allow a PP3 to be used as power. The LEDs were considered essential for ease of use.

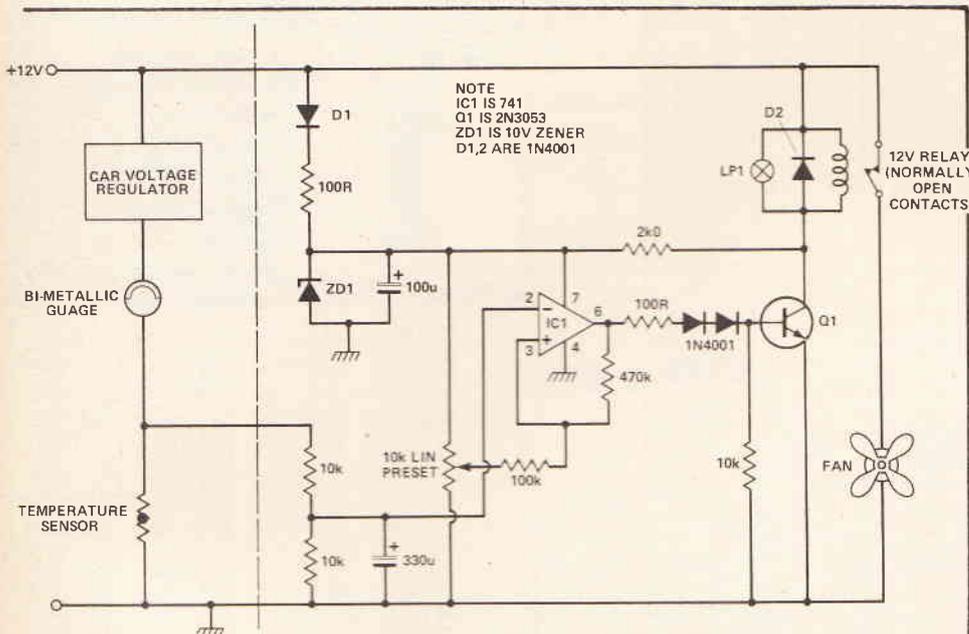
The device can be conveniently constructed in an aluminium box measuring 10x10x4 cm, with the input socket arranged so that the input plug connects the negative supply.

By using various combinations of sockets, the device can be utilised in many more audio signal rerouting applications, eg, by using the A and B return sockets and output only, (with a dummy plug inserted into the input socket to provide power) the box can be used as a single selector.

The 470k and 100k resistors provide a certain amount of hysteresis and the two diodes prevent the transistor turning on due to offset of the op-amp. The fan may run for a few seconds when the ignition is initially turned on. This may be prevented by increasing the 100uF capacitor to a few thousand uF, but I find this useful as otherwise in winter the fan may not run for weeks on end.



NOTE
IC1 IS 4016
IC2 IS 4015
IC3 IS 4011
Q1,2 ARE ANY MEDIUM GAIN
SMALL SIGNAL NPN TRANSISTOR
e.g. BC109 etc.



NOTE
IC1 IS 741
Q1 IS 2N3053
ZD1 IS 10V ZENER
D1,2 ARE 1N4001

Car Fan Control

J. N. Swanson,
Sheffield.

If, like me, you own an old car with a conventional fan, driven from the engine, a worthwhile improvement can be obtained by fitting an electric fan in its place. These can readily be bought for about £5 from a scrap yard. The advantages gained are better fuel consumption and lower engine noise particularly at high revs.

A problem arises in finding a suitable switch to operate the fan at the required temperature. Most of the

switches fitted to the cars are fitted in a threaded hole in the side of the radiator which means that most scrap yards are unwilling to separate the two. For this reason I have designed a circuit to switch on the fan using the existing temperature sensor for the temperature gauge.

The voltage regulator on the car usually works by interrupting the supply so as to provide an average level of about 10V. Because of this, a fair bit of smoothing is required in order to stop the fan switching on and off with the regulator. A zener diode provides a 10V supply for the op-amp and the reference voltage.

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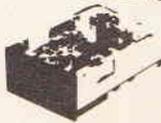
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LIGHTSAVER

Here's a nifty little circuit that should be of universal applicability, wherever there are lightbulbs that get switched on and off a fair amount. Circuit by Kevin Jones.

Incandescent lamps almost invariably 'blow' when they are first switched on. The reason for this is that the cold resistance of the filament is very much lower than the hot resistance, with the result that a very large current can flow at switch on while the filament is heating up.

Filaments are, obviously, designed to withstand this surge, otherwise incandescent lights would not exist. However, part of the art of the manufacturer is not to 'over-engineer' a project (or, to the cynical, not to make products that last too long). This means that the average domestic light bulb can stand this sort of treatment for only so long before succumbing.

There is a way of reducing the stress on the filament, however, and this is by implementing zero-crossing switching. In this, the initial current into the filament is allowed to flow only when the instantaneous voltage of the AC mains is well away from the peak voltage. In the circuit given here, the maximum voltage at turn-on will be 80 volts.

Looking at Fig. 1, we can see the effects of this. In the worst case, the light switch might close at or just before point B or B', with the result that the filament will have 80 volts applied to it immediately, and the voltage will then rise steadily to the peak voltage of 339 volts; this worst-case example is rather better than the normal possible worst case of the filament having 339 volts applied to it when it is cold.

However, most of the time, the switch-on will occur somewhere between B and A' or B' and A, with the result that no current will flow until A' or A. The lamp will then be subject to an extra warm-up period of A' to X' or A to X before commencing the first full half-cycle at zero volts.

Construction And Testing

Firstly, and most importantly, we must point out that this circuit deals with mains voltages and should be treated with all due

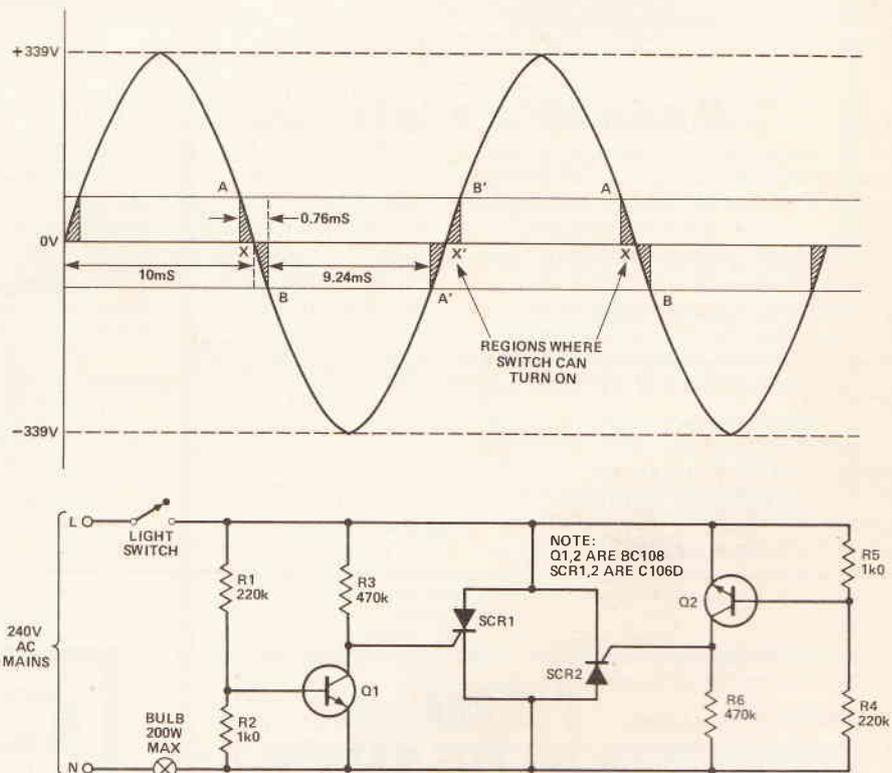


Fig. 1 (top) Switching waveforms for 'zero-crossing' switching.

Fig. 2 (above) diagram of the Lightsaver.

respect — we want to keep our readers. In particular, it should either be mounted in a plastic box using nylon screws or in an earthed metal box. The terminals specified are not designed to take a mechanical pull from the leads, so you must arrange for the cable or flex connecting to the unit to be firmly anchored by some other means.

With regard to assembling the PCB itself, note that the centre leads of the SCRs should be cut; the metal tab should be secured to the PCB using a metal screw (M3.5 or similar size) to complete the circuit, as the tabs are joined to the SCR anodes. If you use alternative SCRs to the type specified, check the pin-out.

HOW IT WORKS

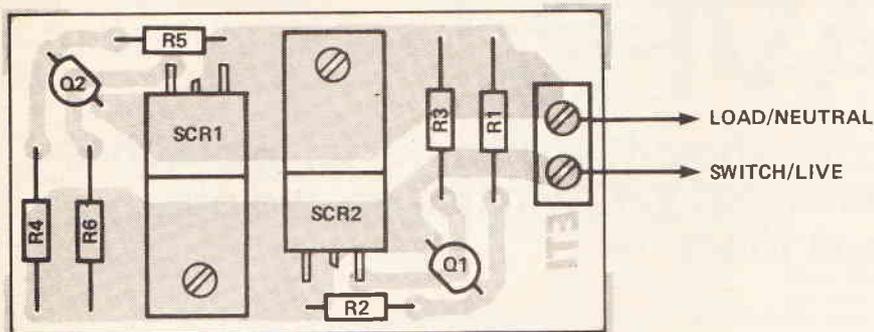
Up to about 80V, R1 and R2 cause there to be less than 0.4V between the base and emitter of Q1. This is too small to switch the transistor on, so the current flowing through R3 is directed to SCR1.

Above 80V or so, Q1 conducts and the gate of the thyristor is held low. This prevents it from switching on; if the lamp switch is flicked on at this moment, the circuit will wait for the mains voltage to fall again before switching the SCR on.

It was considered that the easiest way of maintaining operation during the negative half-cycle was to duplicate the circuit the other way round; hence R4-6, Q2 and SCR2.

R1 and R2 must be selected so that the voltage across R2 never exceeds the maximum V_{EBO} of the transistor, and the value of R3 must be sufficiently high for it to be able to cope with the power it will dissipate when Q1 is conducting and the resistor is effectively clamped across the mains.

PROJECT: Lightsaver



PARTS LIST

RESISTORS

R1,4	220k, 1/2 W
R2,5	1k0, 1/4 W
R3,6	470k, 1/2 W

SEMICONDUCTORS

Q1,2	BC182L
SCR1,2	C106D or similar (400V 3A)

MISCELLANEOUS

PCB; PCB mounting screw connector, two way (suitable for mains voltage); M3.5 (or similar size) short bolts & nuts; case to choice.

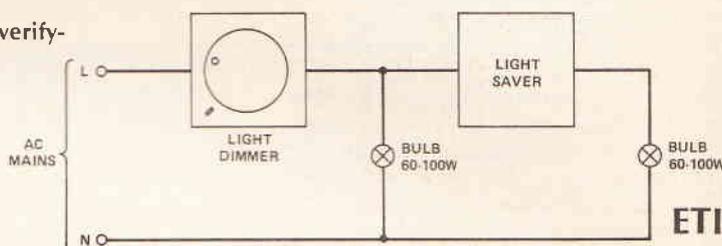
BUYLINES

If you have trouble finding any of the parts for this circuit, maybe you should take out a subscription to Hobby Electronics, or, worse, Computing Today.

If you want to check the action of the lightsaver, then you can use the circuit shown in Fig. 4, in which a dimmer is used to pick out those sections of the waveform in which the Lightsaver should be operating. The bulb attached to the Lightsaver should be on for very low and very high settings of the dimmer and should have approximately the same brightness as the other bulb (if the two wattages are the same).

polarities of the mains waveform. With some dimmers the bulb controlled by the Lightsaver may not come on for one of either the low or high settings (possibly even both), and this will probably be due to a rather limited range of phase-angle being available from the dimmer.

Fig. 4 Method of verifying circuit action.



Some flickering in the transition regions between on and off as the dimmer is varied is normal, and is due to (inevitable) discrepancies in the turn-on point for the two

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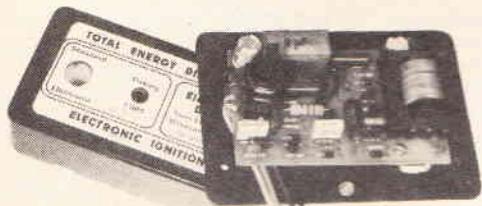
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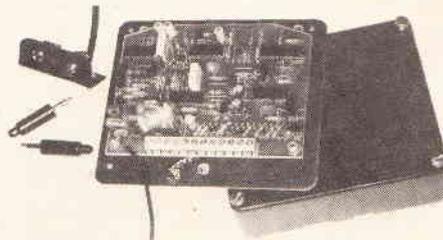
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Write For ETI

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We don't bother with the bureaucracy for Tech Tips — all you do is to send in your idea, stating clearly if you want an acknowledgement of receipt. If possible, please type your explanation of why the circuit is different, what it does and how it works, on a separate sheet from the circuit diagram; both sheets should carry your name, address and the circuit title. We'll let you know (within a month or so) if we want to use your Tech Tip.

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OOPS!

We have in the past published small corrections to projects on the letters page, and major corrections separately. From now on corrections will appear on this page, and will be repeated for several months (just to increase our embarrassment). If a correction is too large to fit on here, we will publish it just once, but will note the fact that a correction does exist, and that copies of it can be obtained from us provided you send in an SAE. But please — request copies only if you really do need them; if this service is abused, we may be forced to withdraw it.

Programmable Power Supply (January 1983)

Lasca Electronics have now moved to Module House, White Parish, Salisbury, Wiltshire SP5 2SJ.

Flash Sequencer (July '83)

Q1 should be BC184L; Q2-5 should be BC182L.

Telescope (August 1983)

We had a shower of annotation falling off our diagrams! On Fig. 1, C19 (below IC14) was not labelled nor was Q2 (above R11), and there were two C23s — one should be IC22 and it doesn't matter which. In Fig. 5, IC12 was not labelled. Unfortunately, there was a mistake in the correction (blush!): C14 is the 22 μ tant on the -5 V line.

Graphic Equaliser (August 1983)

D2 and D3 are shown the wrong way round in the power supply circuit diagram on page 20.

Universal EPROM Programmer (August 1983)

Quite a few sillies here! On the circuit diagram (page 46), C6 is 100u and C9 is 100n, not the other way round as given. Some bars were omitted from note three of Table 1 on page 48: it should have read "CE/PGM (27 series) is equivalent to PD/PGM (not PD/PGM) (25 series)." The penultimate sentence of the first paragraph on page 50 should read "... adjust RV1 for a potential of +25 V at IC10 output." On the overlay, IC7 is between SK2 and SK1, IC6 is between SK1 and C10, IC11 is between R7 and R10, R3 is between R2 and Q2, and Q7 is between Q6 and Q8. A link is missing between IC7 and SK1, and the unidentified pins at the right hand end of SK3 are the +5V line. Finally, C10 appears twice in the parts list but only the first entry is correct, and the second DIL socket should, of course, be 8, not 80, way.

Z80 Controller Computer (August 1983)

On the overlay, SW1 is the rectangle beside ICs 5 and 6, C6 should be shown between ICs 3 and 7, and a link through has been missed — to the right of pin 18, IC11.

Typewriter Interface (October 1983)

There are two errors in Table 1 on page 24: location 3C should contain E7 and location 3F should contain 5F.

Car Alarm (October 1983)

In the semiconductors section of the parts list, Q1, 2, 5, and 7 should be BC212L, Q3 should be BC182L, and Q4, 6 should be TIP31 or BD131. There was also another (inconsequential) silly but we bet you've already spotted that one!

Tech Tips (October 1983)

Ramped Pulse Generator For Stepper Motors — pin 1 of IC2 should be grounded, the Ramp Up and Ramp Down inputs accept negative, not positive, going pulses, and IC7 should be a 4011 rather than a 4001.

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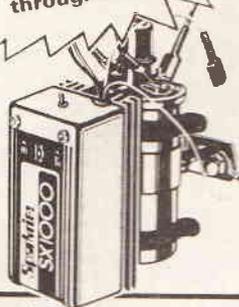
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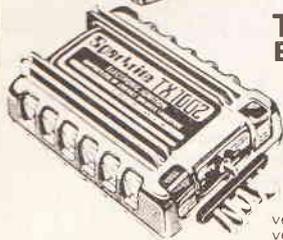
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AT-40 Electronic Car Alarm

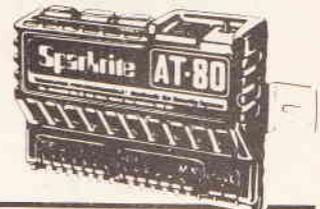
- Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed using concealed switch ● 30 second delay-to-arm: 7 second entry delay ● Can alternatively be wired to exterior key switch ● Flashes headlights & sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Low consumption C-MOS circuitry



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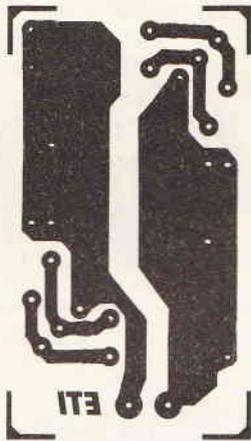
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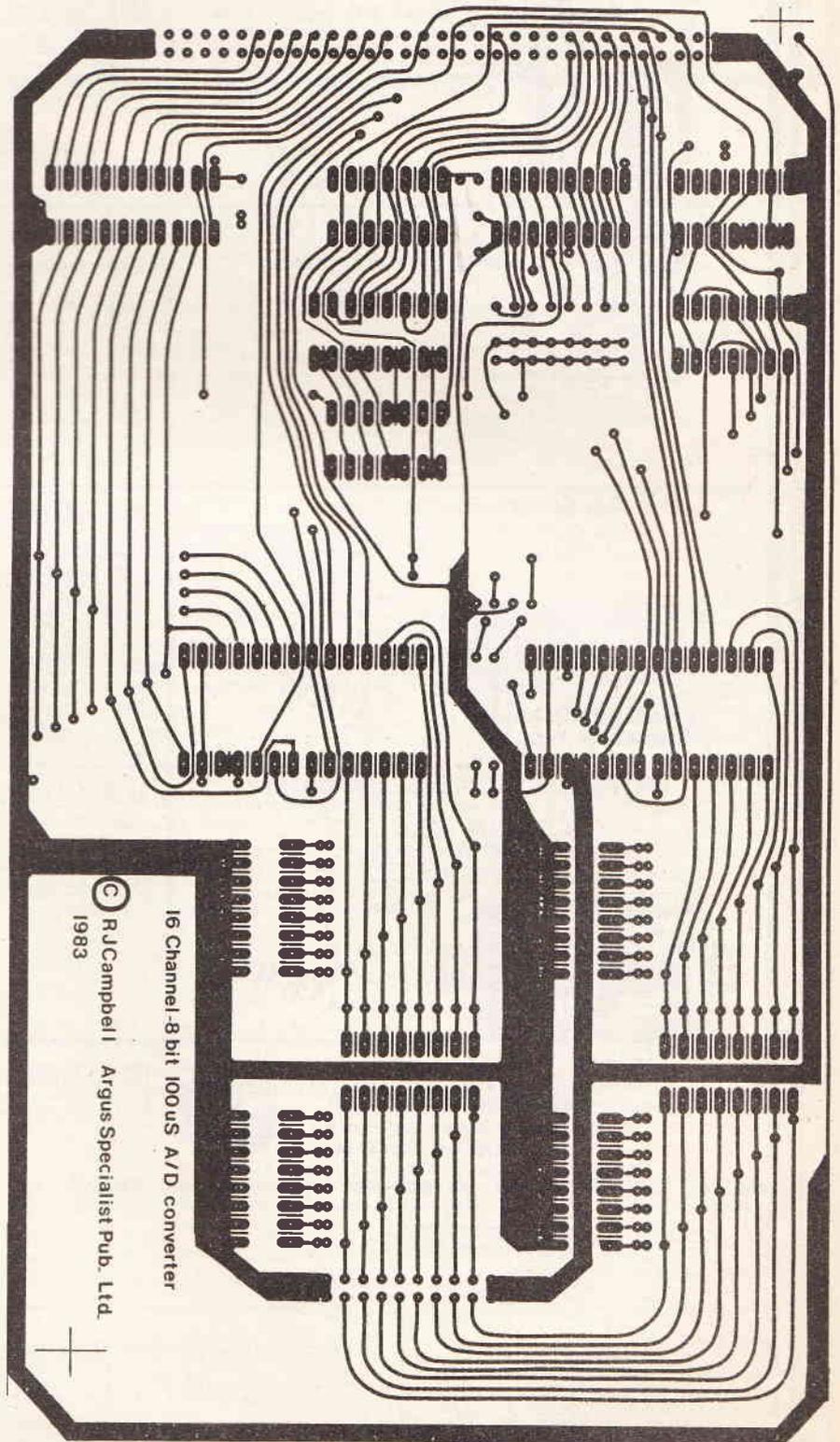
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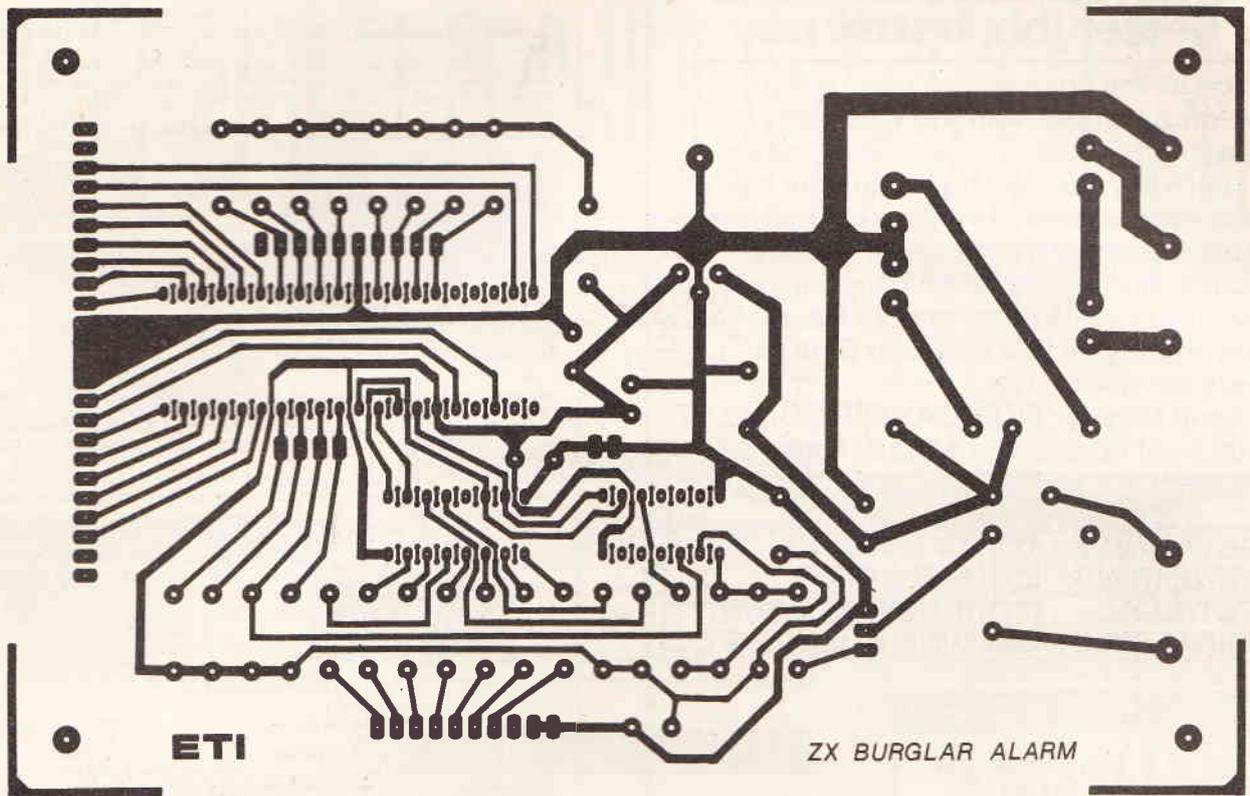


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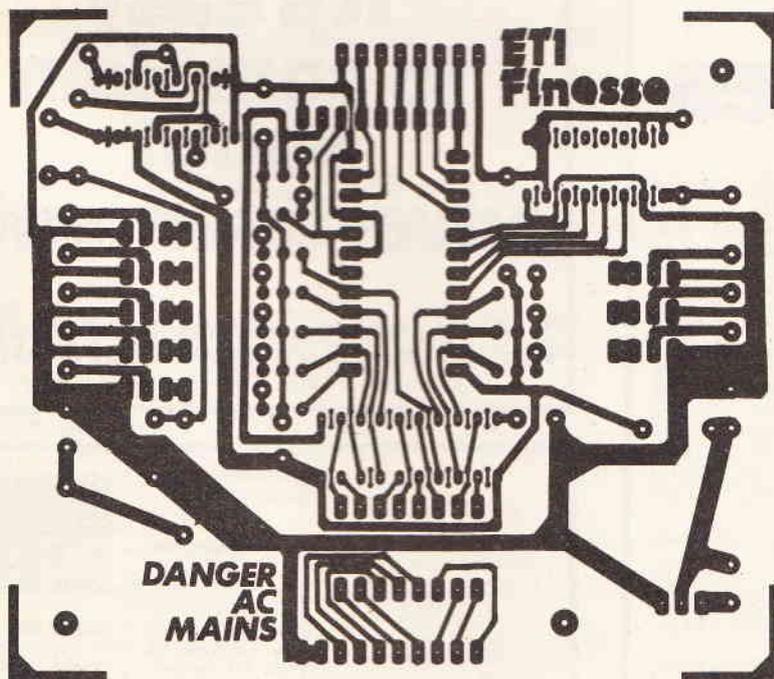


16 Channel A to D Board

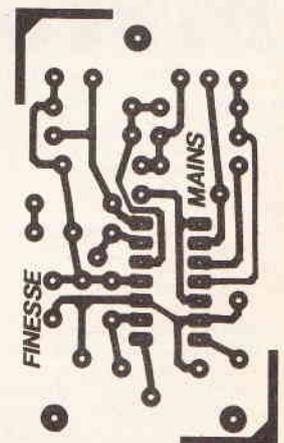
Note that we have reproduced here only the underside pattern of the double sided board. The upper side pattern consists only of links, and it should be possible to produce this from reference to the overlay diagram, Fig. 3 on page 21. At a pinch, you could even use fine wire links as shown in the picture of our prototype on the cover. Just to keep everyone happy though, we will try and find space for the other foil pattern in a future issue.



ZX Burglar Alarm



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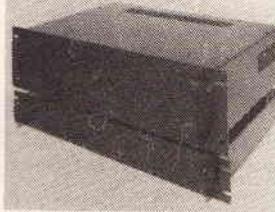
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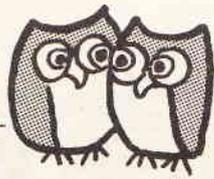
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Low-price robots from POWERTRAN

— hydraulically powered
— microprocessor controlled

The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry. With prices from as low as £425, even the home enthusiast can aspire to his or her own robot.

Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to 6 independent axes are capable of simultaneous operation with positional control being provided by means of a closed-loop feedback system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.



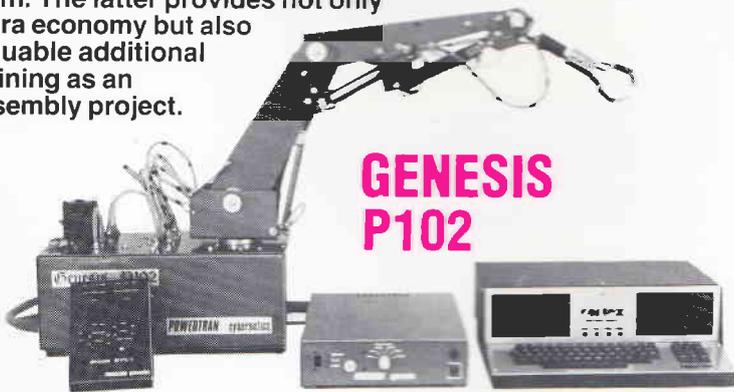
GENESIS S101



GENESIS P101

The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing.

All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project.



GENESIS P102



HEBOT II Turtle-type robot

For under £100, Hebot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors coupled to its shell return data about its environment to the computer enabling evasive or exploratory action to be calculated.

The robot connects directly to an I/O port or, via the interface board, to the expansion bus of a ZX81 or other microcomputer.

HEBOT II

Weight 1.8kg
complete kit with assembly instructions **£85**
Interface board kit **£10**

MICROGRASP



A real, programmable robot for under £200! Micrograsp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and servo controlled, giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP

Weight 8.7kg, lifting capacity 100g
Robot kit with power supply **£145.00**

Universal computer interface board kit **£48.50**
23 way edge connector **£2.50**
AX81 peripheral/RAM pack splitter board **£3.00**

GENESIS S101

Weight 29kg, lifting capacity 1.5kg
4-axis model (kit form) **£425**

5-axis model (kit form) **£475**
5-axis complete system (kit form) **£737**
5-axis complete system (ready built) **£1,450**

GENESIS P101

Weight 34kg, lifting capacity 1.8kg
6-axis model (kit form) **£675**
6-axis complete system (kit form) **£945**
6-axis complete system (ready built) **£1,650**

GENESIS P102

Weight 36kg, lifting capacity 2kg
6-axis system (kit form) **£1175.00**
6-axis system (ready built) **£1950.00**
Powertran Cortex microcomputer self-assembly kit **£295.00**
ready-built **£395.00**



POWERTRAN cybernetics

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ALL PRICES ARE EXCLUSIVE OF VAT

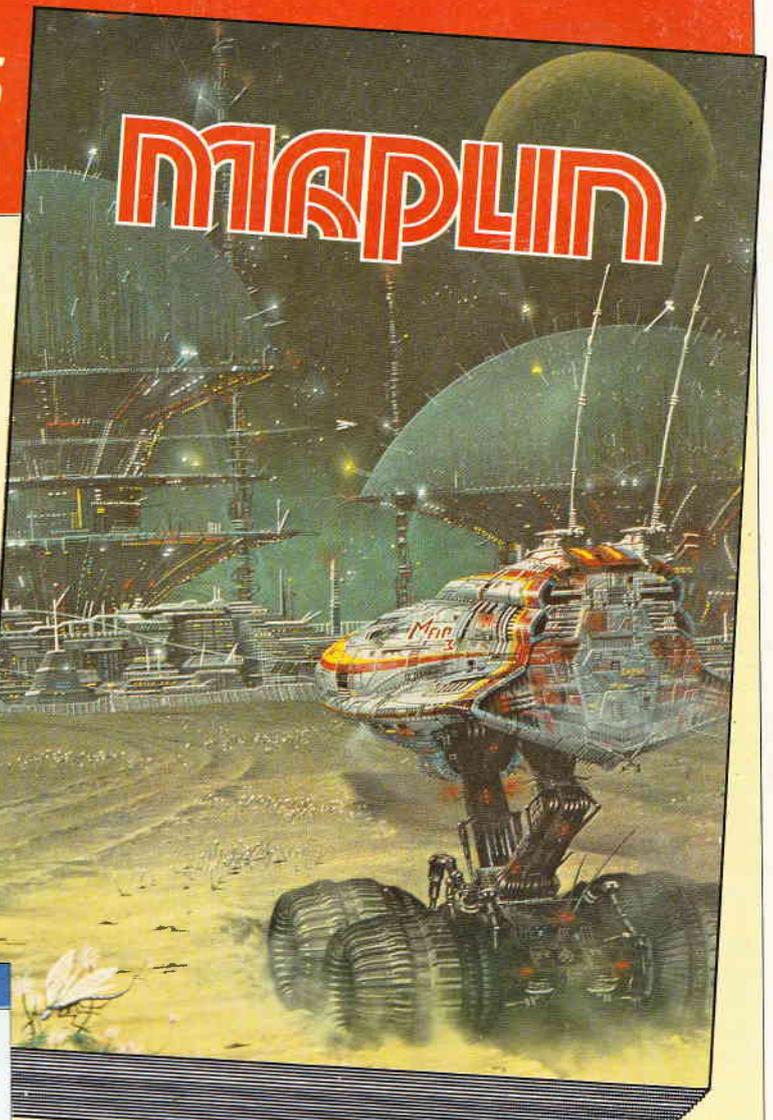
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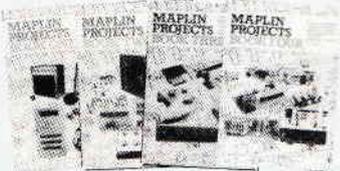
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